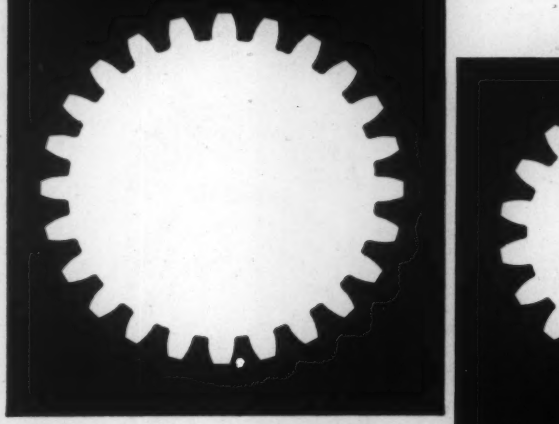
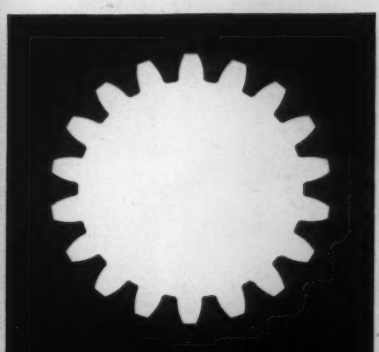
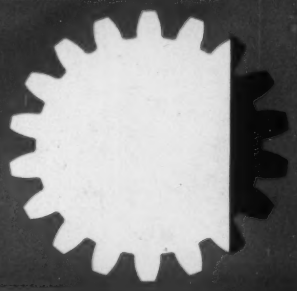
DECEMBER 12, 1957

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY







STAMPED GEARS

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FARNSWORTH

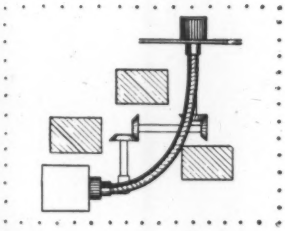
S.S.White

Flexible Shafts Eliminate Unnecessary Parts

One manufacturer used flexible shafts to replace 35 parts in a Hydraulic Power System . . . cut costs by 90%. Four flexible shafts replaced a 35-part remote-control system . . . simplified design . . . made assembly easier . . . eliminated alignment problems . . . improved performance!

This is only one of hundreds of remote control and power drive problems these quality flexible shafts are solving in every industry today. Can S.S. White flexible shafts help improve *your* product? Perhaps make it lighter in weight . . . cut production costs . . . eliminate unnecessary parts?

If you'd like to know more about flexible shafts, the advice of our engineers costs you nothing. Just write to



S. S. White Industrial Division, Dept. 4, 10 East 40th Street, New York 16, N. Y.
Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

S.S.White
FIRST NAME
IN FLEXIBLE SHAFTS

Useful data on how to select and apply flexible shafts! Write for Bulletin 5601.

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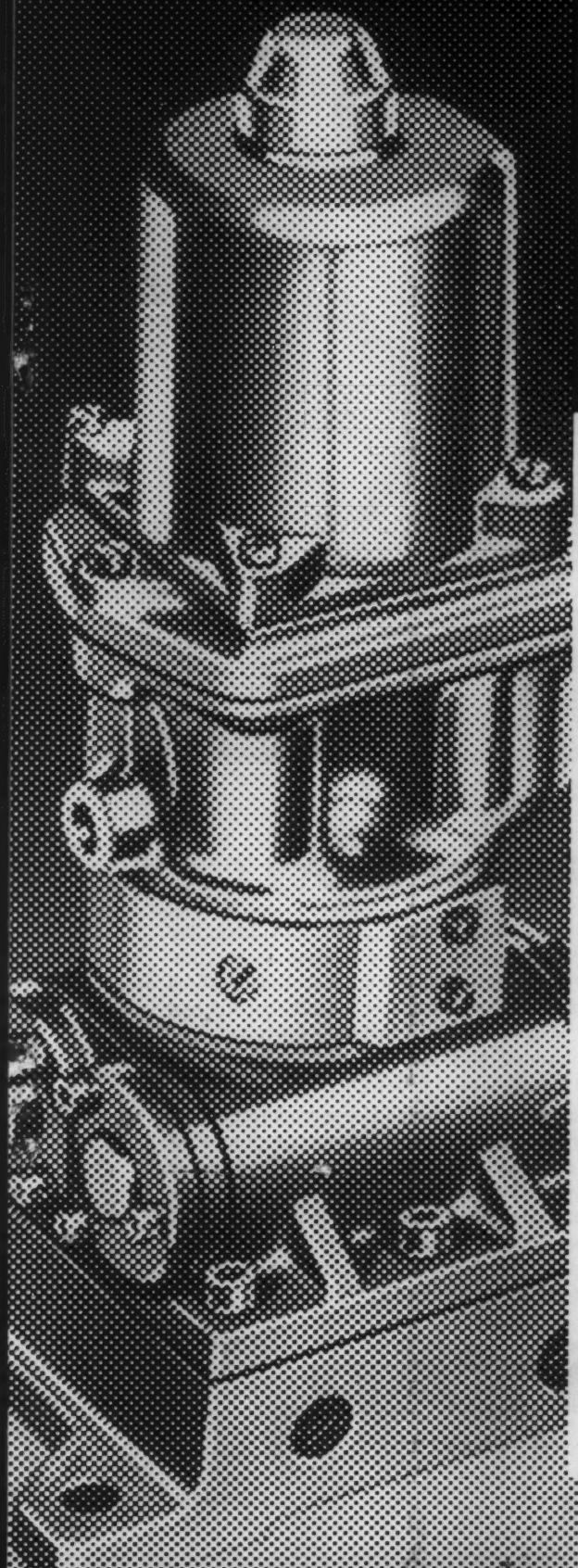
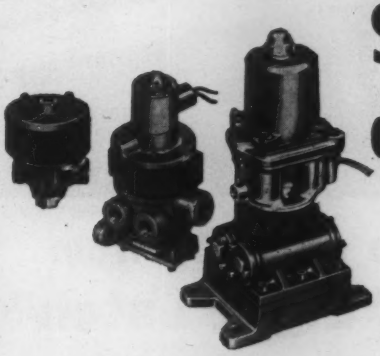


NEW-A totally different type momentary!

Ross Skyline **Double Stroke adapter**



Each time the single solenoid strokes the valve reverses and stays put

An air operated model is also available with which the valve reverses and stays "put" with every air impulse (pressurizing and exhausting) delivered to the single pipe opening in the head. The secret is a two part cycle in the adapter wafer which inserts between any skyline head and any skyline body. Hundreds of applications. Save space. Save cost. Save maintenance. *Do jobs never before possible.* Write for full details in bulletin 316.

Air Controls With Engineering and Ingenuity

Ross OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVENUE • DETROIT 3, MICH.

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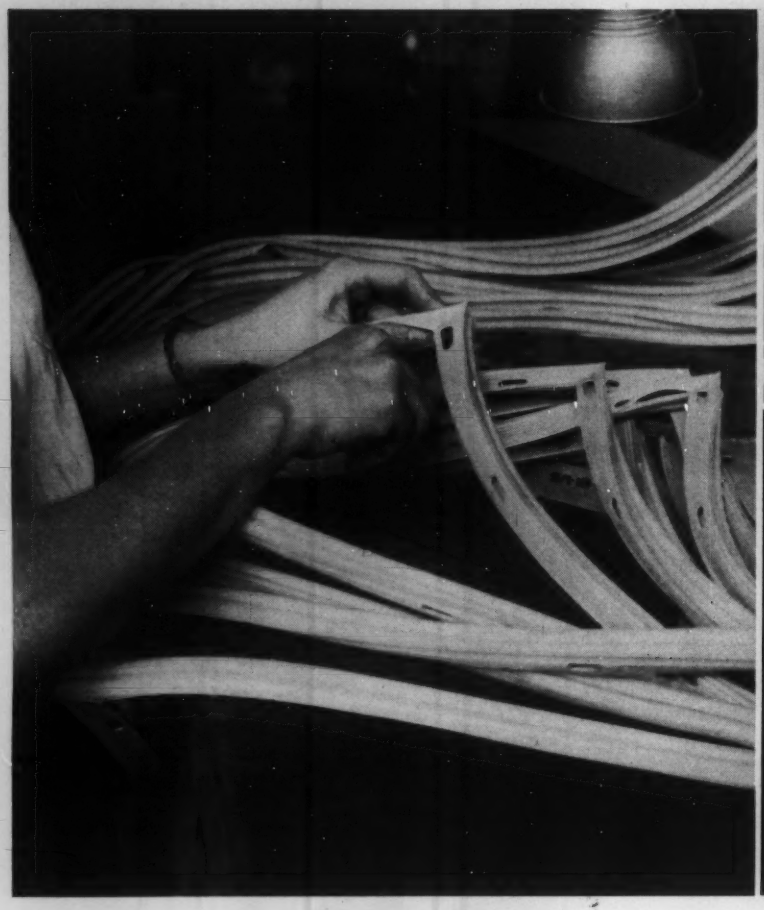

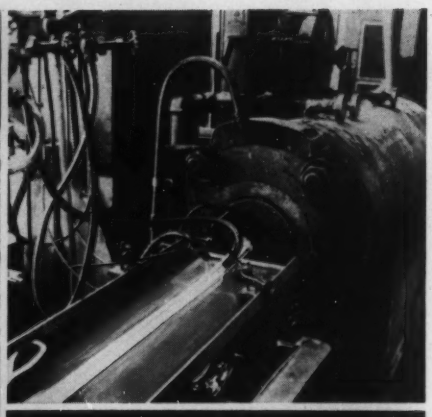

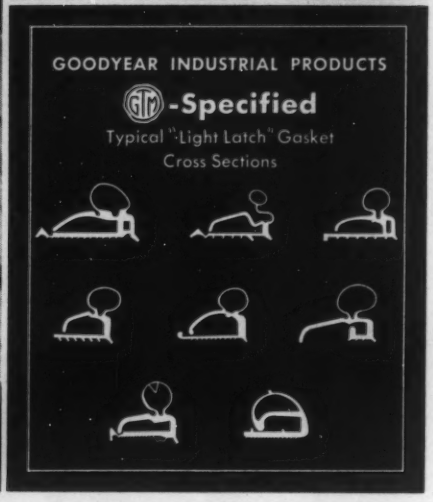

What can you learn from
the "Light Latch" Gasket Story?

Here was a problem facing the entire appliance industry—how to prevent the tragedy of curious children becoming entrapped in idle refrigerators.

The solution lay in designing a door that could be easily pushed open from the inside. Though low pressure latches were available, they wouldn't work against the husky vinyl gaskets then being turned out. A gasket was needed that would seal the full perimeter of the door under a fraction of the former pressure, as well as lasting the life of the machine.

Finally a leading manufacturer turned the problem over to the G.T.M.—Goodyear Technical Man. Immediately a corps of designers and compounders set to work and, in surprisingly short time, had the answer. Result: Most of the leading refrigerator manufacturers buy their "light latch" gaskets—designed and compounded to their own particular needs—from Goodyear.

The moral of the story: For complete product design, expert mold and custom compounding, backed by the facilities and people to turn out quantities of quality molded or extruded plastic parts on "spec" and on time, see the G.T.M. or write Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

MOLDED AND EXTRUDED PLASTICS by

GOODYEAR

THE GREATEST NAME IN RUBBER

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December 12, 1957 Volume 29—No. 25

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

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Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday and copyrighted 1957 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

24% savings in finishing costs and better forming with Formbrite

FINE DESIGN and a rich luster finish are the main sales features of the quality brassware manufactured by Coronet Brass, Incorporated, New York City.

Coronet's finishing operations, therefore, are of primary importance. Hearing about the outstanding polishing characteristics of Formbrite®, Anaconda's superfine-grain drawing brass, the company placed a trial order. The planter, jardiniere, and "leather-on-brass" waste basket shown above were among the first products made of Formbrite.

After several months of operation, Mr. Maurice Schulman, owner of Coronet Brass, summarized the company's experience with Formbrite as follows:

1. "We estimate that there is a saving of approximately 24% in our initial cutting operation, which represents about three-quarters of the complete finishing operation for our brassware.

2. "We further estimate that there is an approximately 20% difference in the color-buffing operation—the final step before the brass is lacquered.

Formbrite
Superfine-grain drawing brass
an **ANACONDA®** product
made by
The American Brass Company

3. "We have found that, on a small beading operation performed on one of our items, there is a time saving of about 50% due to the fact that Formbrite does not wrinkle as does regular brass in our automatic beading machine. The operation used to call for extreme vigilance, wasted much time. Now this substantial saving is possible because of Formbrite's springiness."

Find out for yourself. Formbrite is a premium product, yet it doesn't cost a penny more than ordinary drawing brass. Try it and see for yourself how its superfine grain, excellent drawing properties, strength, and scratch resistance can help you cut costs and make a better product. Get a sample or a trial batch. See your American Brass representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont., Canada.

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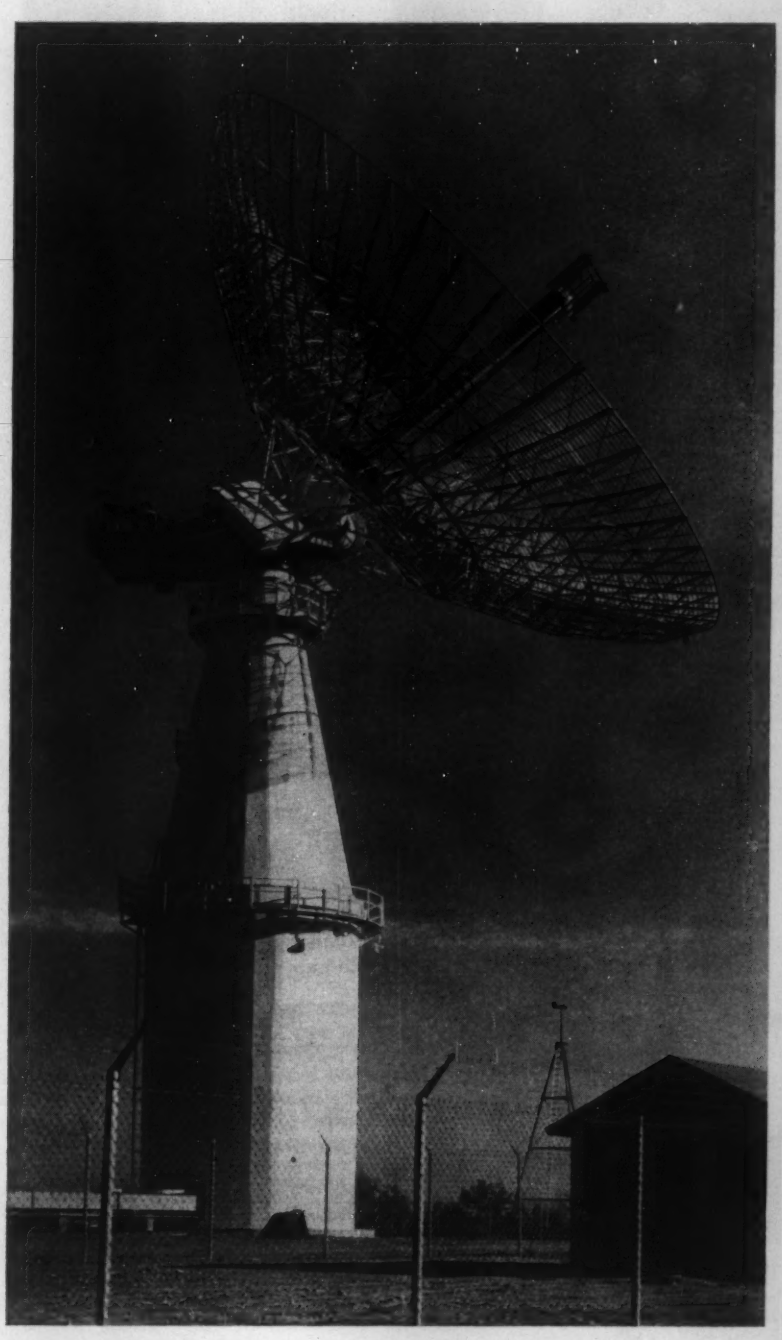
Engineering News Roundup



Sputnik and Muttnik Passes Seen Here

Huge Radar Pinpoints Satellite Positions

LEXINGTON, MASS. — A powerful, long-range radar has been detecting the Russian satellites, Sputniks I and II, at remote distances from Millstone Hill in Westford, Mass. Completion of the high-powered radar was made public by Lincoln Laboratory of the Massachusetts Institute of Technology only after it had been used to observe the satellites. Partly as a result of radar sightings, the orbit characteristics of the Sputnik satellites have been determined with considerable accuracy.

From observations of Sputnik II, measurements of range, elevation, bearing, and Doppler frequency were made. Height of Sputnik II, when first observed, was 152 mi.

Designed primarily for the study of problems in missile defense, the Millstone radar will provide valuable information on the operation and applications of high-power, long range radar; also assist research of the radio effects of meteors and the aurora. Designed especially for the radar and its associated equipment is a transistorized digital computer, as well as high-power klystron tubes, 11 ft high, that provide the transmitting power.

The antenna system consists of a parabolic reflector, 84 ft in diam, mounted on a tower 90 ft high. The rotating portion weighs 90 tons. Antenna can sweep sky with horizontal rotation of 360 deg, vertical elevation of 90 deg.

Minute bending of the antenna tower caused by uneven heating by the sun was outside tolerance. Bending was minimized by painting to the strength and rigidity of

Tender for Offshore Drilling Is Self-Contained Operation

Up-To-Date Ship Is Offshore Workhorse

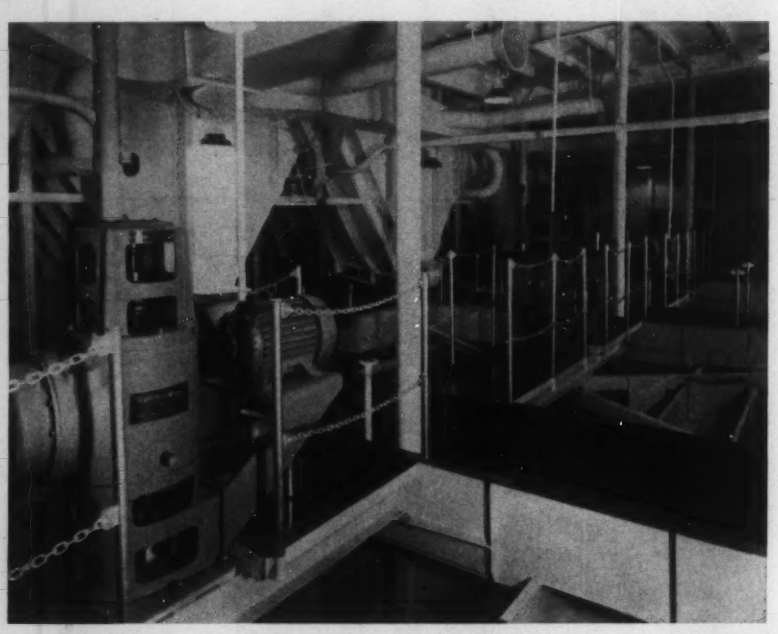
BEAUMONT, TEX.—A new tender for offshore drilling platforms boasts seaworthiness of a conventional ship as well as a helicopter deck, electrical and machine shops, air conditioned living quarters for 58, and a large revolving crane. Built by the New York Shipbuilding Corp., the *Howard S. Cole Jr.* has recently been commissioned by the Coastal Marine Drilling and Construction Corp.

Target for design was a completely self-contained tender, providing its own propulsion power. The new ship is capable of transporting and storing drilling mud, cement, drill pipe, and fresh water.

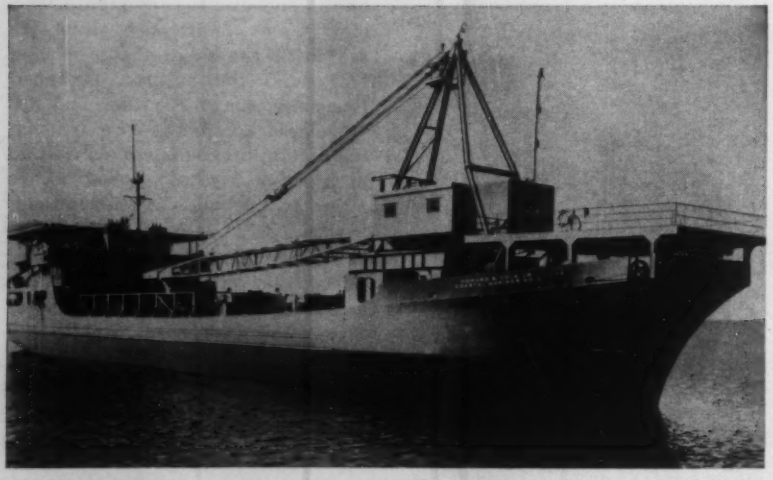
The Texas deck of the after superstructure forms a 56 by 60 ft helicopter deck complete with safety net and is lighted in accordance with CAA requirements.

Mounted on the main deck forward is a large revolving crane, equipped with air controls. Through the use of a specially designed swing motor and control system, the crane is capable of swinging in a 6-deg uphill or downhill list condition.

The crane has adequate capacity to erect the drilling platform foundation, drive the necessary piling to anchor it, and to erect the drilling structure and heavy drilling machinery. The crane is used also to handle casing, mud, cement, drill pipe, and supplies necessary in the support of an offshore drilling operation.



Aboard offshore drilling platform tender, four heavy duty agitators mounted in the mud tanks provide the means of building up mud weight quickly in an emergency. Tender storage capacities are 5000 sacks of bulk mud, 1800 barrels of liquid mud, 2500 sacks of bulk cement, 12,500 barrels of drilling water, and 500 barrels of drinking water.



Of all-welded construction, offshore drilling platform tender is 272 ft long with a beam of 56 ft and is 22 ft deep. Tender has main deck and one complete lower deck, a raked stem and modified cruiser stern.

Magnetic Flux Turns Corners With Ease in New Metal

Silicon Iron Crystallinity Permits Right-Angle Paths

PITTSBURGH—Crystal arrangement in a new magnetic steel permits metal to be magnetized along either of two axes. According to Westinghouse engineers, this permits magnetic flux to "turn corners" readily.

Conventional steel now used in magnetic cores is singly oriented. It can be easily magnetized along one axis only, the direction of steel

Front Cover

"The little gear who wasn't there" might be the subject of artist George Farnsworth's front cover. Faced with the problem of typifying stamped gears, George decided to skip the gear entirely and concentrate on what's left after the gears are blanked out. You'll find the gears themselves on Page 161.

... Fluid Power news

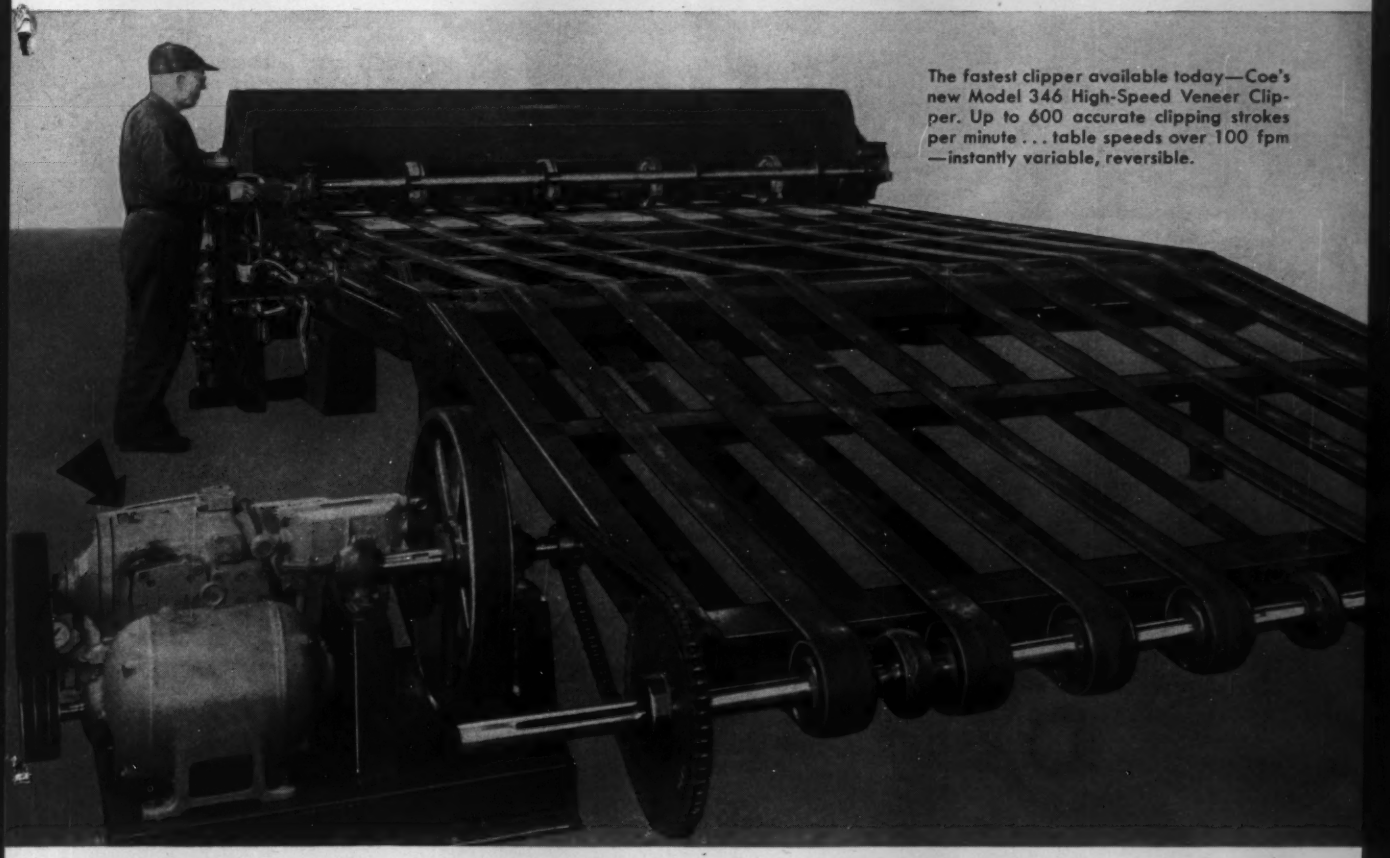
REPORT No. 11-501 HIGH-SPEED FEED TABLE DRIVE AND CONTROL

From Oilgear Application-Engineering Files

HOW OILGEAR "*ANY-SPEED*" DRIVES BOOST VENEER CLIPPING SPEEDS—ACCURACY

CUSTOMER: *Coe Machinery Company, Painesville, Ohio*

DATA: For high-speed, accurate sizing of single sheets of veneer in motion, table feed drives for new veneer clippers must be instantly, infinitely variable, and instantly reversible to clear slips and jams at the knife if ragged or defective veneer is encountered. Complete control should be through a remote, single lever. Drive must be rugged, compact, trouble-free . . . provide smooth, stepless, shock-free, uniform acceleration and deceleration from zero to maximum in either direction . . . easy to install and maintain.



The fastest clipper available today—Coe's new Model 346 High-Speed Veneer Clipper. Up to 600 accurate clipping strokes per minute . . . table speeds over 100 fpm —instantly variable, reversible.

SOLUTION: Shown above as standard equipment on Coe's new Model 346 high-speed veneer clippers are Oilgear heavy-duty DHC-88, two-way, *Any-Speed* Transmissions. Coe reports, "Variable table speeds are instantaneously afforded in forward and reverse. These drives are arranged to give belt speeds from approximately 70 to 175 fpm by movement of a single lever. The quick stop and reverse of this drive is very desirable if ragged or defective veneer slips and jams at the knife. This drive is equally desirable when the table drive is used to unload veneer storage decks between the clipper and the lathe." Oilgear *Any-Speed* Drives bring out the best in machines due to the many other "plus" features such as: cushioned power; automatic overload protection; automatic electric power conservation; totally sealed—safe in hazardous atmospheres; constant torque; automatically self-lubricated to insure long, trouble-free life.

Machinery manufacturers and users agree that for superior heavy-duty performance on sawmill carriages, gang-saw feeds, conveyors, capstans, winders, centrifuges, textile, paper, tape, rubber, and food processing equipment—it's Oilgear . . . for the lowest cost per year!

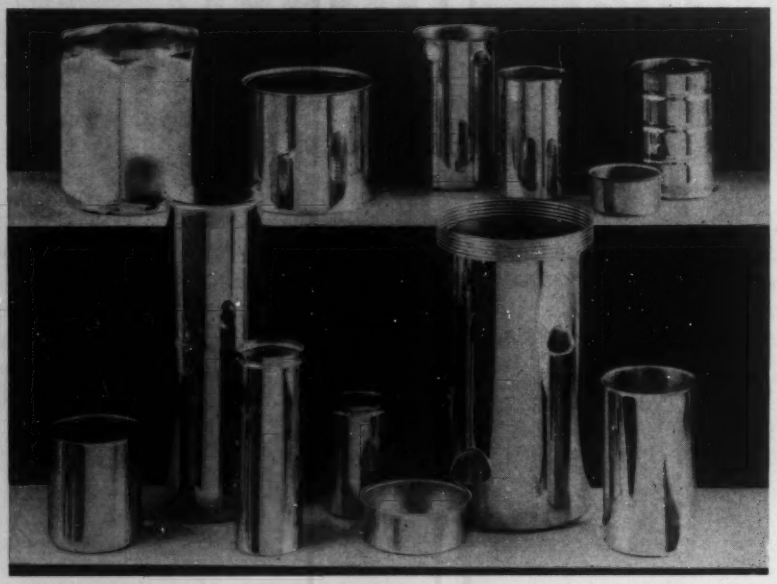
For similar practical solutions to YOUR linear or rotary drive and control problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements directly to . . .

THE OILGEAR COMPANY

Application-Engineered Fluid Power Systems

1568 WEST PIERCE STREET · MILWAUKEE 4, WISCONSIN

Please direct inquiries to advertiser, mentioning MACHINE DESIGN



LONG AND SHORT aluminum cans are produced by new deep draw process. Seamless, one-piece can bodies are drawn in single stroke on double-end horizontal presses at Kaiser Aluminum's container plant. Wall thickness of rigid cans can be as thin as 0.005 in.; light weight reduces shipping costs. Naturally bright cans are used for packing foods and industrial products.

rolling during manufacture. Hence, for best magnetic characteristics, the core is built up of straight strips of metal laid at right angles into a rectangular shape.

With the new material, L, E, U-shaped, or even rectangular punchings can be stamped from a sheet of steel in one operation. Besides improving the magnetic path, this simplifies core construction.

Called Cubex steel, the new metal has about the same chemical composition as the standard magnetic material—about 3 per cent silicon, 97 per cent iron. The real difference between old and new comes from steel processing from rough sheet into the final product. The process for producing Cubex steel has been demonstrated to be operative in sheets thick enough for use in large transformers and motors.

Westinghouse engineers, however, emphasize that, thick or thin, Cubex steel has not yet graduated from the laboratory. Uses requiring only thin sheet are expected to be first commercial applications, possibly within a few months.

System Sends Computer Data Over Conventional Voice Line

CHICAGO — A 40-channel system transmits computer information by wire or radio. The system, developed by the Collins Radio Co., is designed for reliability and efficient use of bandwidth.

Called "Kineplex," it is described as a data transmission system which will operate in a single telephone voice band of standard quality. It will accept at its input, with suitable conversion, binary data from any source. The system is designed to accept 40 channels of 60, 75, or 100-word-per-minute telegraph data or, with accessory converting equipment, data from standard business machine cards at a rate of 200 cards per minute, or binary data from high-speed magnetic tapes not to exceed 3000 bits per second.

Laboratory tests conducted over both radio and wire circuits have shown the system to be tolerant to most commonly encountered transmission distortion and noise.

Topics

Two and one-half billion electric light sources of more than 10,000 types and sizes will be made by the lamp industry in the U. S. this year, according to Donald L. Millham, GE Lamp Div. vice president and general manager. The production exceeds output during the first 30 years after Edison developed the light bulb.

• • •

Cleverer, these Chinese—engineers in Communist China claim to have developed the ability to produce major engineering feats without Soviet assistance. The country has 800,000 engineers and technicians, compared with 170,000 in 1952.

• • •

Dizzy Canadian robot reveals sensations of a man under extreme accelerations and simultaneous complex motions of different types. An apparatus consisting of an assembly of miniature gyroscopes, each about the size of a spool of thread, attaches to the head and provides information on the subject's equilibrium, his idea of where he is, and where he thinks he's going. Study was carried out by Dr. W. H. Johnson of the Defense Research Medical Laboratories, Toronto.

• • •

Detecting heart beat in an unconscious, pulseless person is possible with a small, portable device called a cardiac monitor. It uses transistors, is battery-operated, and provides a continuous, instantaneous visual monitoring of heart rate and rhythm.

• • •

Nuclear nomenclature applied to the first atomic-powered U. S. merchant ship results in the designation *NS Savannah,* NS for nuclear ship in place of SS for steamship. The *NS Savannah* is the namesake of the *SS Savannah,* first steamship to cross the Atlantic.

• • •

First vertical oxygen storage tubes have been installed by Air Products Inc. for Granite City Steel Co., Granite City, Ill. The storage bank, made up of 30 tubes which stand 80 ft above the ground, holds 125,000 standard cubic feet of 99.5 per cent pure oxygen stored under 450 psi pressure.

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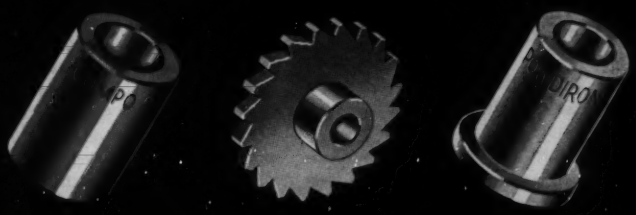


Watch BOUND BROOK ADS for SMASHING NEWS in 1958 -- our 75TH year

BOUND BROOK OIL-LESS BEARING CO.
ESTABLISHED 1883 BOUND BROOK, NEW JERSEY

Pioneer in POWDER METALLURGY BEARINGS & PARTS

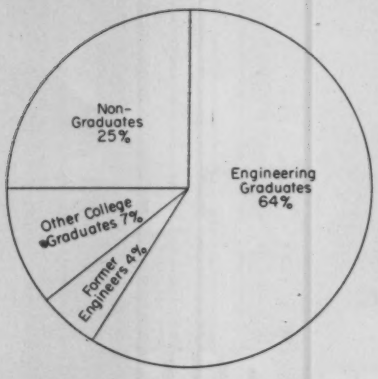
Engineer Shortage Measured, Remedies Posed

Is There a Shortage? Report Says "Yes"

Facts Show Engineers Dynamic Force in Economy

NEW YORK—Has there been, is there now, and will there be a shortage of engineering manpower? According to a just-published research report, the answer is a resounding "yes."

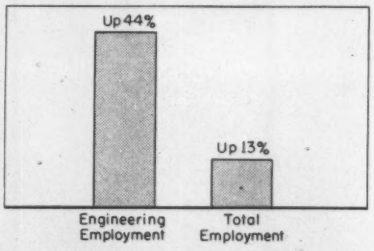
Since 1880, the report prepared by Deutsch & Shea Inc. for Industrial Relations Newsletter Inc. shows, the size of the engineer labor force has increased more than 20 times as fast as the total civilian labor force. From 1950 to 1957, the pattern of growth was marked by three distinct factors: First, total expenditures for research and development increased from $2.9 billion in 1950 to $6.5 billion in 1956. Second, total expenditures for new plants and equipment rose abruptly with a larger share of these expenses being channeled to introduce new products and processes. Third, the increase in capital investment was much greater in industries that are the primary employers of engineers. Those industries that employ large numbers of engineers expanded considerably more than the economy as a whole.



Entrants to the engineering field averaged about 46,000 every year for the period 1950-1957 for a total of 321,600. This total includes new engineering graduates, estimated at 204,800, approximately 79,400 without college degrees, some 22,000 graduates with degrees in other fields who are able to apply their training to engineering, and about 15,400 former engineers working in other fields who returned to their profession.

The National Science Foundation in an independent survey of industry's needs in the scientific field reported, "A sizable number of firms said they had been forced to curtail projected increases in their research and development programs because of the lack of qualified personnel."

In the distribution of the major engineering groups among specific industries, five of the eight major groups of engineers are largely em-



Increase in the engineering profession compared with increase of the labor force as a whole, 1950—1957.

Society Says Engineering Shortage Is, Isn't Too

Lays Down Seven Points To Clear Conflict in Views

WASHINGTON — Recent developments have provided fresh evidence for those who contend that there is a severe shortage of engineering and scientific personnel and, at the same time, for those who maintain that there is not a shortage.

The National Society of Professional Engineers has observed and studied various statements, reports, and analyses. Here quoted is part of the NSPE statement:

1. Special action to increase today's supply of engineers is not considered necessary or desirable since engineering enrollments are at an all-time high and are continuing to increase.

2. An artificial stimulation to further increase enrollments in engineering will severely handicap institutions that devote adequate attention to the capable students.

3. Assumption that Russia launched the earth satellite before the United States solely because it had trained more scientific personnel in recent years than this country, we believe is not valid and could lead to unwise and damaging decisions. We believe it would be more logical to assume that the controlling factors were priorities assigned to money and emphasis, rather than a shortage of technical personnel in the U. S.

4. Emphasis now more than ever should be placed on quality rather than quantity. Potential engineers should be better grounded in fundamentals when they enter the engineering educational program and should be better informed as to the qualifications essential for an individual to become a successful engineer.

5. In view of the present limitations of facilities and faculties, the substantially increased enrollments in our engineering institutions are causing serious difficulties at the present time. Any program which will substantially add to the present number of students must include means to resolve these limiting factors.

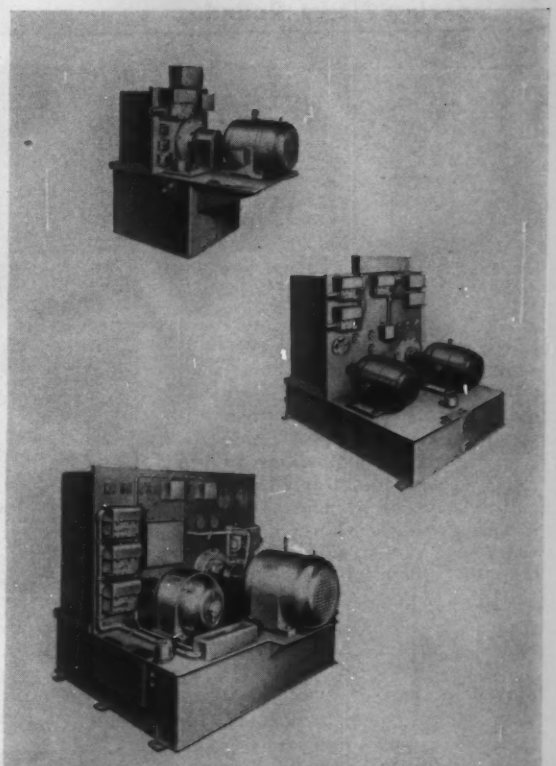
6. It should be emphasized that projects such as the earth satellite, guided missiles, etc., depend on highly advanced technology—a mere increase in numbers of those with first degrees will not provide the type of highly advanced technical knowledge which is necessary. It should also be noted that any program based on present needs will not succeed in solving today's technological problems. A program starting today will not produce a single highly qualified engineer or scientist for at least six years.

7. Experience has shown that we have wasted engineering talent by using it at a level below that which it is capable of performing. Improved utilization of engineering talent can do more for an immediate need than any other single program.

BARNES

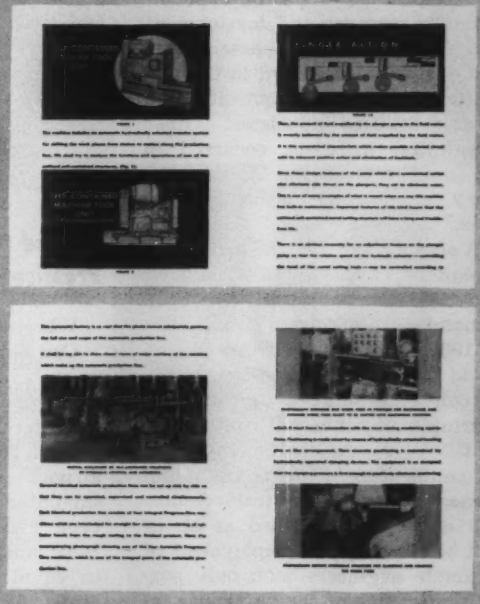
HYDRAULIC POWER UNITS

The various elements — supported by the units — are so arranged as to allow INDEPENDENT SERVICING by electricians, hydraulic servicemen, fixture servicemen, tool makers, etc.



THE RHYTHM OF PRODUCTION

depicting AUTOMATIC MASS PRODUCTION TECHNIQUES



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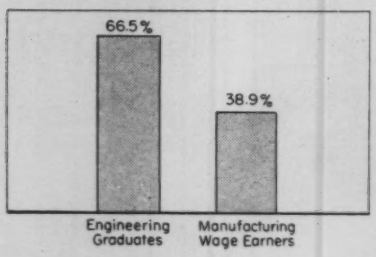
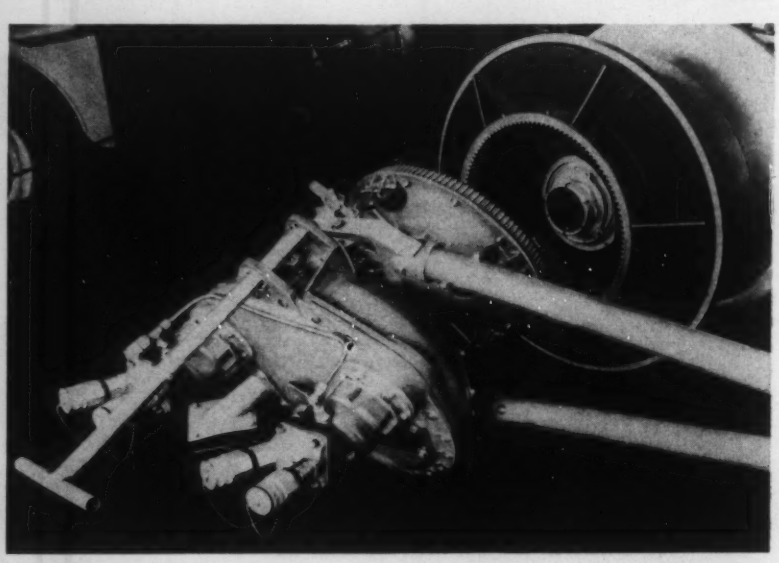


Engineers' starting salaries from 1950 to 1957 increased more than four times as much as the cost of living; significantly more than salaries of other workers. Because salaries of other occupations are to some extent administered upward and salaries of engineers are not, it seems that the shortage of engineers was even more substantial than the salary figures indicate.

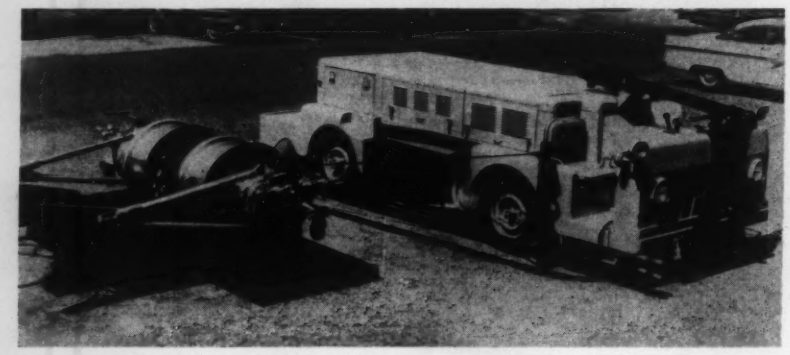
ployed in one or two industries. This suggests that demand for these groups of engineers depends not only upon general conditions throughout the economy, but also upon current conditions in these particular industries.

During the period 1950 to 1957, the largest increases in expenditures for research and development and expenditures for new plants and equipment occurred in the aircraft, electrical equipment, and electric utilities industries. Other substantial increases occurred in the nonelectrical machinery, primary metals, and chemical industries.

It seems clear that the accessions of college graduates between 1957 and 1960 will not satisfy the total demand for engineers from 1957 to 1960. The gap between the demand for engineers and the supply of college graduates to the engineering profession will continue to be filled by men partly trained to fill engineering jobs. In high skill areas, shortages of trained men will either not be filled at all or will be filled by the employment of graduate engineers with only partial knowledge of the particular industrial field. In less skilled areas, the excess of demand over supply will doubtless be met by the employment of men without college degrees.



Prototype power vehicle and "wheel mover" units transmitted driving power directly to B-52 landing gear with brakes set to simulate aircraft. The wheel moving hydraulic motor here is in process of being attached to a ring gear on the shoe of a landing gear wheel. The V-bar leading off right is a torque reactor attaching to hub of landing gear rear wheel.



Ground Movement of Giant Jets Promised by Wheel Mover Units

Wheel Mover Plus Power Units Can Supply All Ground Needs

STAMFORD, CONN. — Taxiing giant jet aircraft by moving its wheels to and from the loading gates of airport passenger terminals was simulated recently when a prototype "wheel mover" propelled a B-52 landing gear with brakes set to equal weight load of the aircraft. The "wheel mover," developed by Consolidated Diesel Electric Corp., transmitted torque directly to wheel rims at speeds up to 5 mph against braking power to 200,000 lb of inert weight.

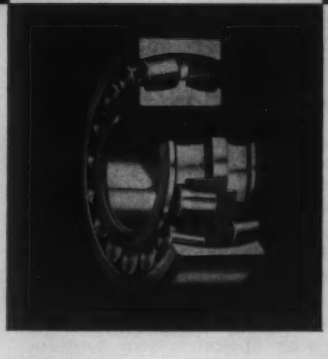
Aircraft and power vehicle with wheel mover sets in place.

Control of the speed and direction of each wheel was maintained

TORRINGTON SPHERICAL ROLLER BEARINGS

The Manitowoc 4500 Power Shovel is equipped with Torrington Spherical Roller Bearings in 7 critical heavy-duty, high-speed applications where they eliminate stress concentrations and provide long service life.

How to get a big lift



Torrington Spherical Roller Bearings in critical positions on the Manitowoc shovel help it handle tons of earth and rock with ease and speed!

Accurate roller-to-race conformity and positive roller guidance of Torrington Spherical Roller Bearings insure long, trouble-free service. They are used on the swingshaft, PTO sprocket support, front drum main shaft, front and rear drums, countershaft, PTO pilot and vertical travelshaft. These self-aligning bearings insure smooth anti-friction operation and efficient transmission of power despite heavy radial and thrust loads, housing misalignment and shaft deflection.

Wherever heavy-duty construction equipment is at work, Torrington Bearings are contributing to efficiency and long service life. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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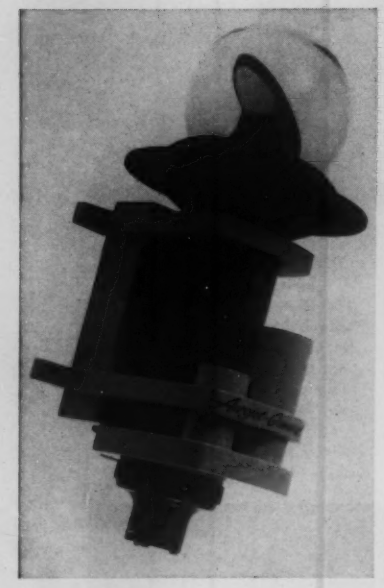
by a small remote handset which in actual operation would be handled by the aircraft pilot.

Towing devices have been tested and found wanting. Due to the great weight of new jets, towing places strain on the aircraft frame. Also, pilot had no control in ground movement of multimillion-dollar craft.

The "wheel mover" units are planned for use with other elements to make up a system of servicing the Boeing 707, Douglas DC-8, Convair 880, and Lockheed 188 with pneumatic, electrical, and ground movement power.



AIRCRAFT ANTICOLLISION MIRROR, infrared sensitive, is being tested at Aerojet-General Corp. System consists of a horizon scanner which protrudes from the aircraft and continuously sweeps 360 deg of sky in azimuth and ±7½ deg in elevation. Incoming rays from engines of approaching aircraft are deflected downward through an optical system, and focused on a photoconductor cell. From here, information is processed, electrically amplified, and presented to the pilot on a visual indicator. CAA has reportedly claimed that 80 per cent of aircraft collisions — including last year's Grand Canyon disaster—could have been prevented with a similar infrared or electronic instrument.

Not a light bulb inside a coil of wire but metal, suspended in space and heated to molten temperature by effects of a radio field, is shown stirring itself. New process eliminates contamination in research on pure metals.

Ultrapure Metals Yield To Snake Charmer's Wiles

Radio-Frequency Field Floats, Melts, Stirs Metals

PITTSBURGH—Ultrapure metals are being prepared for laboratory study by heating them at 4500 to 5000 F in half a minute or less while floating them in space, free from contact with container walls. Called levitation melting, the technique was developed through combined efforts of scientists at the Westinghouse Research Laboratories and the University of British Columbia.

Levitation melting is used to prepare highly purified laboratory-scale ingots of niobium, zirconium, titanium, molybdenum, and dozens of alloys. Compressed metal powder is placed inside a copper coil which carries a high-frequency electric current. The electric current generates a field of force which floats the metal inside the coil and at the same time, heats it to a white-hot molten mass.

At white heat, metals such as niobium and titanium react chemically with any known vessel in which they are melted. Levitation melting eliminates this problem entirely. No containing vessel is required, since the molten metal floats freely in space, confined only within itself. The whole process is carried out inside a sealed vessel containing an inert gas such as helium or argon, thereby protecting the pure metal from contamination by the air. The

molten metal reportedly even stirs itself, yielding unusually uniform alloys from mixtures of different metals.

HANDFUL OF POWER — 40 lb thrust, 1-second duration—is supplied by this midget, solid-propellant rocket motor. Designed by Atlantic Research Corp. to perform spin and retro functions on Vanguard, the unit is now available commercially. Weight is 0.6 lb, length 4.8 in., diameter 1.5 in. Possible applications include acceleration of small masses, packaged, fast-response thrust services, experimental rocket engineering. The motor has a shelf life of over three years; requires no assembly before use. Igniter is actuated by a 6-v dry cell.

Study Radio Transmission for Vast Reaches of Outer Space

Pave Way for Communication With Manned Space Ships

SUNNYVALE, CALIF. — The problems of sending and receiving space messages and identifying objects far from earth are under study in a large, new space communications laboratory opened recently. Findings by more than 50 Lockheed Missile System division scientists may well pave the way for communication with manned space ships of the future or for the remote guidance of unmanned space ships.

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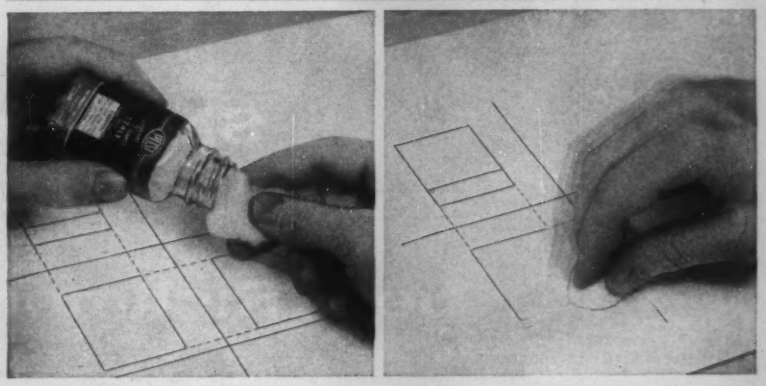
DRAFTING TRENDS



Use of Liquidator makes it easy to erase large areas on POST pencil cloths without affecting the surface.

Improve drawing board cleanliness for better prints

Poor original drawings make poor prints. No matter how good the reproduction equipment, an original that is marred by graphite smears, has become spotted through frequent handling, or has been creased too often will produce a difficult-to-read print.

The standards of drawing board cleanliness that a draftsman establishes for himself and the steps he takes to prevent smearing or spotting of his drawings are as important as his technical skills.

There are two principal causes of poor prints. First are graphite smears. As straight edges, triangles, scales, etc., are moved over a drawing, dust and graphite particles begin to smudge and smear it. In addition when the draftsman's hands touch the drawing they often transfer body oils and tiny bits of dirt which affect reproducing quality.

(l. to r.) POST Liquidator, POST Dry Cleaning Pad, POST Dust-It.

Preventing smears

The easiest way to eliminate smears and spots is to prevent them in the first place. Good clean drafting habits are all important.

Probably the most important precaution to prevent smudging or spotting of drawings is to lightly sprinkle Post's Dust-It over the surface before beginning work. Dust-It cleaning compound prevents dirty drawings (1) by picking up the dirt and (2) by cleaning drafting tools at the same time. It is free from gritty or abrasive substances and does not interfere with the draftsman's work.

Cleaning pads

Should smudges occur they should be removed immediately—preferably with a Post dry cleaning pad. The pad contains a special compound which is sifted in a sprinkling manner through the pad over the area to be cleaned. Then, by rubbing very easily with the pad, graphite smudges disappear without damaging the drawing.

Eradicating unwanted elements

Care in removing unwanted elements is necessary to avoid marring the drawing surface of the paper or cloth. For users of Post's popular pencil cloths, an extremely simple and satisfactory method of eradicating is the use of Post Liquidator.

Applied on POST cloths, Liquidator saves time and labor in erasing large areas. More important, it permits repeated redrawing "good as new" over eradicated areas without change of pencil degrees. This assures identical line uniformity.

For further information on these Post products see your Post dealer or write today to the Readers Service Division of Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.

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ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

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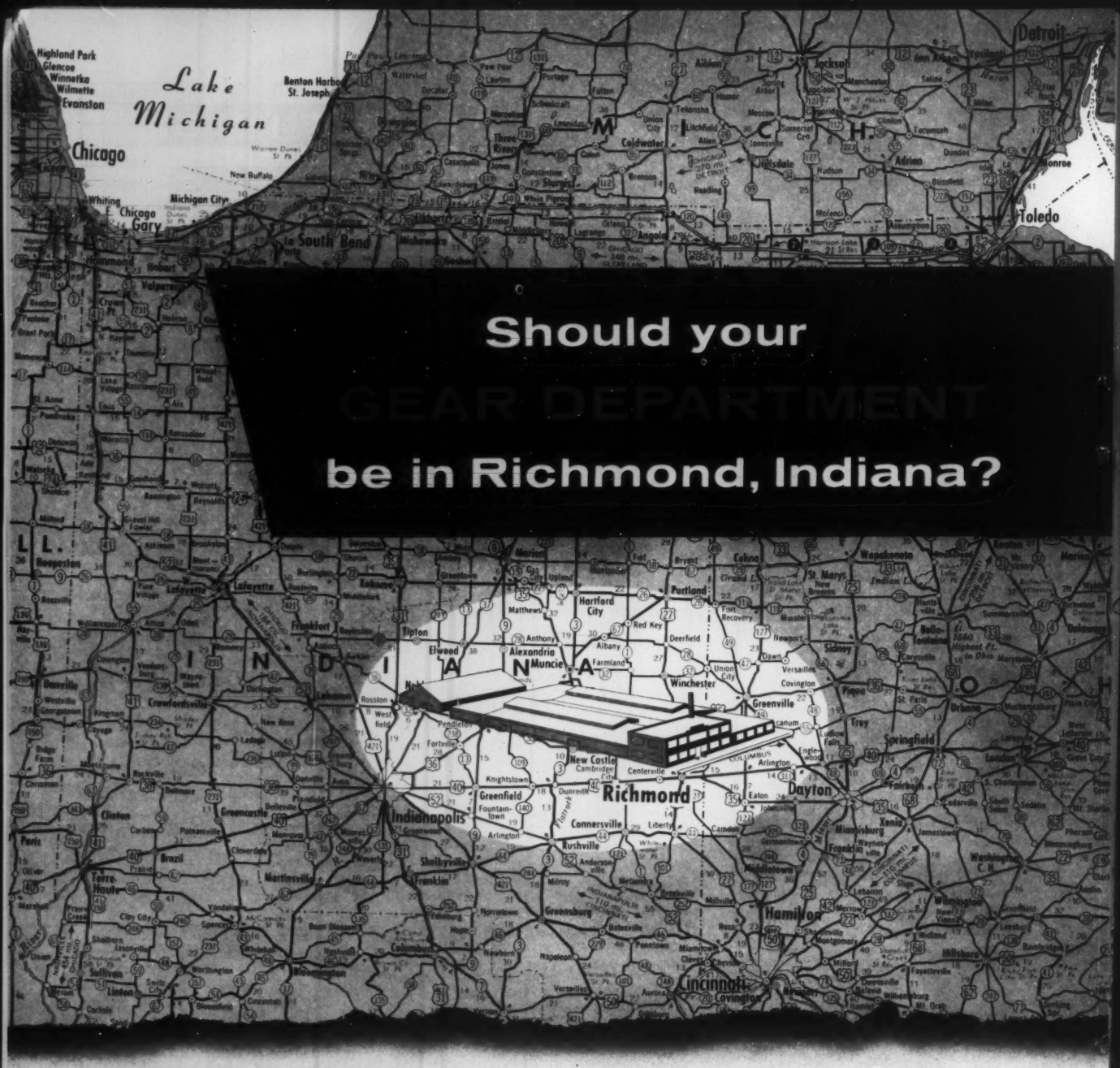

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CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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DEC. 12, 1957

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403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
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422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

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Leading engineers and designers report that Clearprint Fade-Out Paper speeds up their drafting 10 to 15% . . . cuts their costs proportionately. And Fade-Out Paper gives them prints which are sharper and easier to read, because grid lines do not reproduce.

Clearprint's perfect working surface invites pencil and pen — lines are sharp and clean. It withstands repeated erasures, too, without the slightest ghosting.

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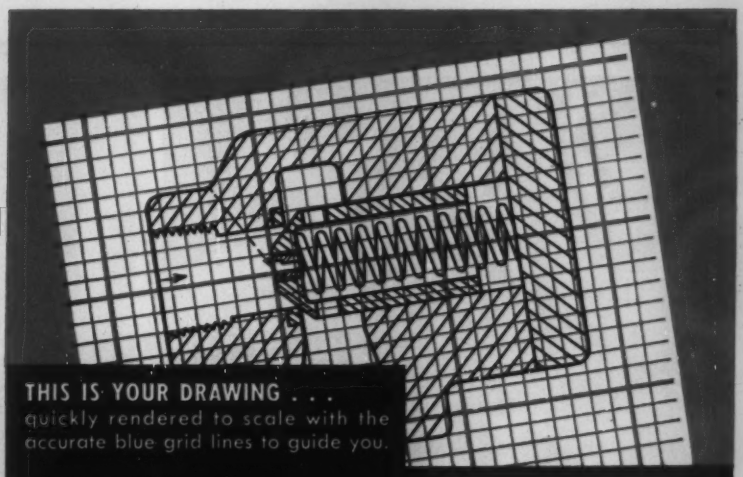

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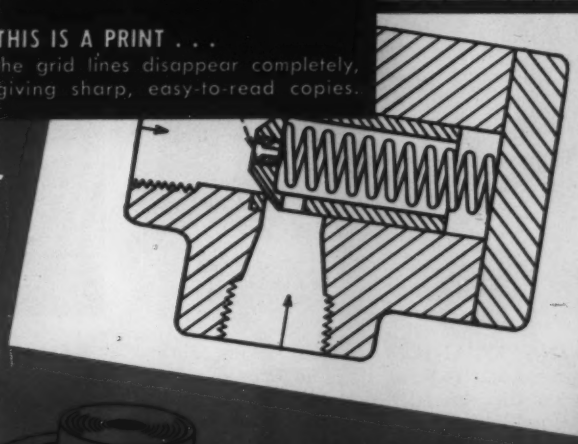

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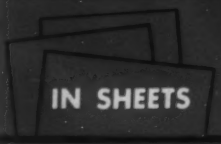

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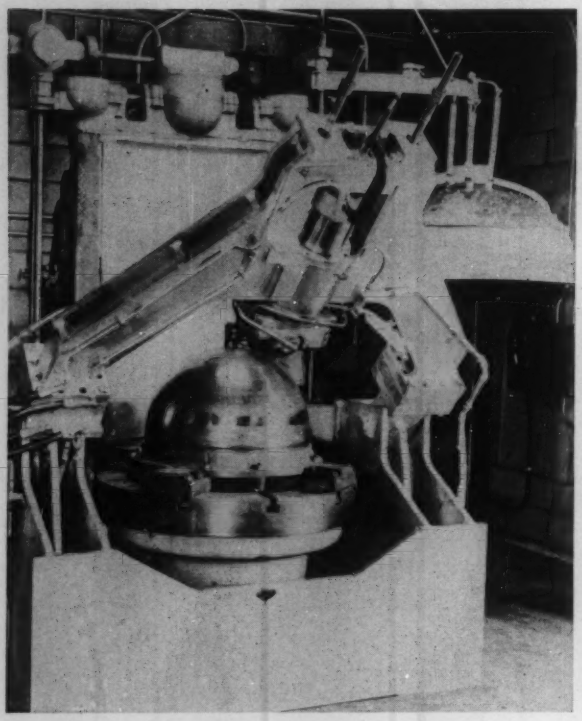
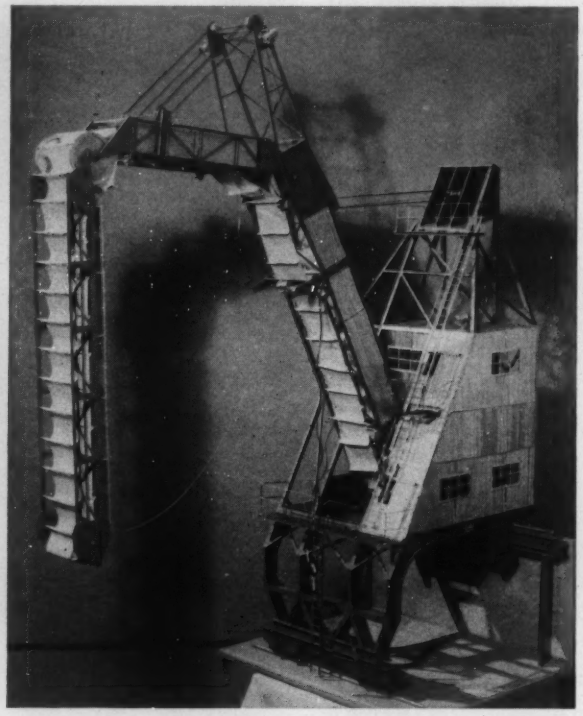


HOT-SPINNING TITANIUM to form strong, lightweight pressure vessels is being done at Titanium Fabricators Inc. on this specially designed vertical spinning lathe. Completely hydraulic, the machine permits close control of speeds, feeds, and pressures. Hydraulic system is rated at 3000 psi—can exert 12 tons of pressure on the small area being formed. Spinning tool is easily removed; can be replaced by machining tools for contour work or for machining edges prior to welding. Circular, preheated blanks used in the process are 6 Al, 4 V titanium alloy, a relatively new heat-treatable alloy developed by the Army.



BANANA UNLOADER with traveling sponge rubber pockets combines speed and careful handling to unload 60 stems of bananas per min. The gantry crane is self-propelled on tracks; has two control stations—one in the cab and a remote position in the ship's hold. Bananas are hand-loaded, one stem per pocket and discharged, gently, on conveyor belts for fast handling. A switch on the bottom of the marine leg automatically lifts the boom if the ship rides upward. An automatic belt takeup adjusts for changes in belt length as the boom moves. George L. Day Co. is building four of the units for the United Fruit Co.

(*Continued from Page* 15)

Subjects under study in the three-story laboratory include: 1. Effect of outer space's cosmic rays on radar and radio signals. 2. Radar pattern presented by various space vehicle and missile shapes. 3. Effect of the ionosphere on such signals. 4. Characteristics of various antennas when installed in missiles.

An anechoic chamber—or "quiet room" measuring 20 by 70 ft—produces electronic conditions to be found 300 miles in space by eliminating all stray electronic signals. Much of the advanced research is being done in connection with the Navy's Polaris ballistic missile.

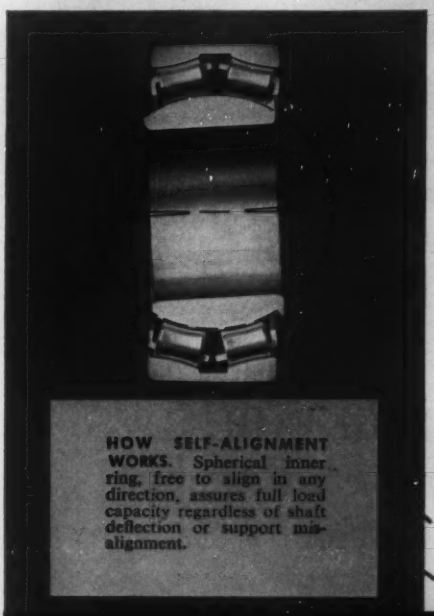
Metal Filters in Complex Shapes Produced by Fiber-Metallurgy

CLEVELAND—Using metal fibers instead of powders, metallurgists at Horizons Inc. are producing complex porous shapes for a number of useful applications. For example, metal filters produced by the new method are claimed to maintain unusually high strength, ductility, and porosity under a variety of conditions—including high temperature. The new technique uses wire in fiber or filament form obtained by a wire cutting or shaving process, in the place of metal powders.

In one method of preparing fiber-metal shapes, felting procedures are used similar to those used in the paper making industry. A suspension or slurry of fiber is deposited as sheet in equipment such as Fourdrinier machines. The suspension is in contact with a porous mold or die. Subjected to a vacuum, the liquid is drawn away from the mold, leaving a mat of fiber on the surface. This surface can be quite complex, to produce similarly irregular-shaped elements.

Physical variations are obtained by controlling fiber length, diameter, kinking, surface roughness, and porosity. Greater strength in a predetermined direction is

self-aligning . . . CAN'T BIND



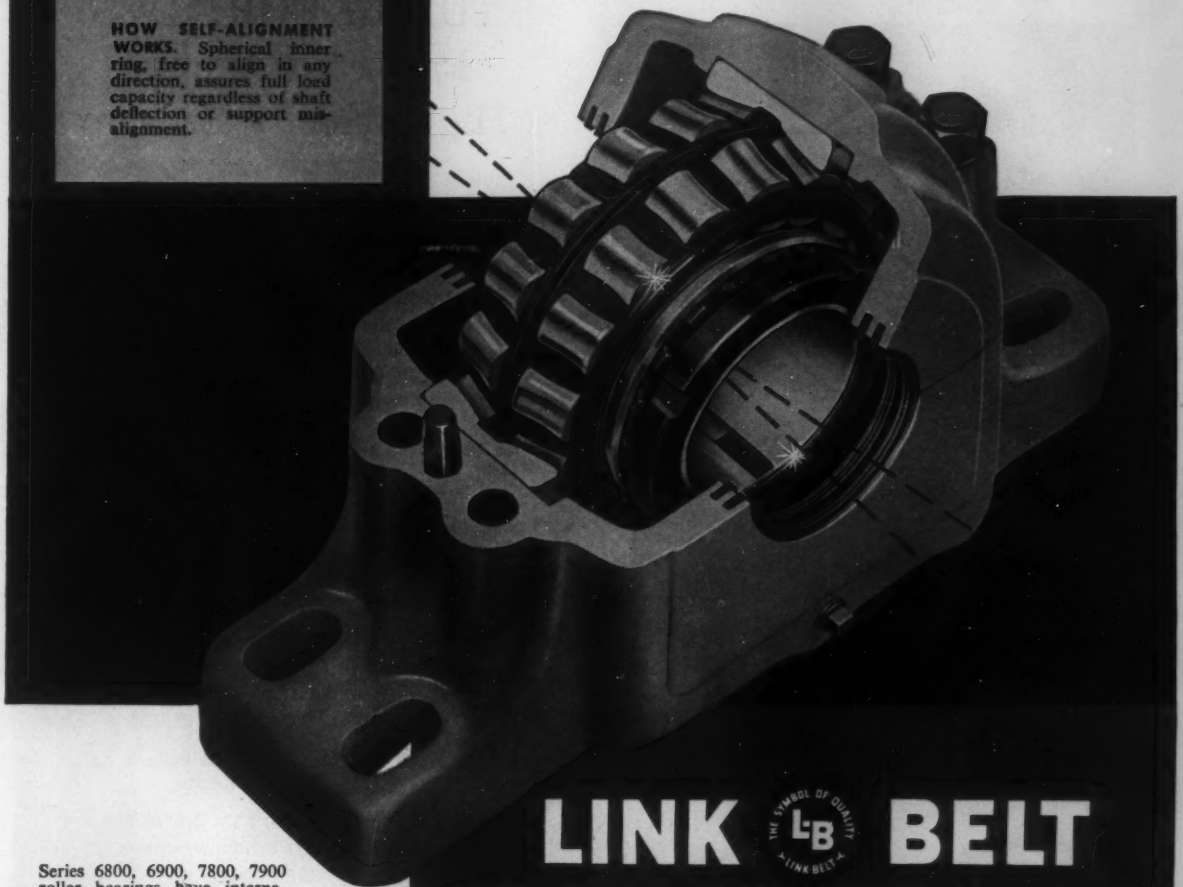
HOW SELF-ALIGNMENT WORKS. Spherical inner ring, free to align in any direction, assures full load capacity regardless of shaft deflection or support misalignment.

Husky bearings in husky housings adjust immediately in any direction

When high-impact loads deal out punishment, shaft deflection may spell a quick finish for ordinary bearings. But this rugged Link-Belt bearing is *self*-aligning . . . won't "pinch" or bind when misaligned.

Complete protection is provided by effective seals which block entrance of dirt, escape of lubricant. Durable housing—machined as two perfectly matched parts provides easy installation without shims or alignment rings.

Get full data on Link-Belt's complete bearing line from Book 2550. Ask any of 40 offices.



Series 6800, 6900, 7800, 7900 roller bearings have internationally standardized boundary dimensions.

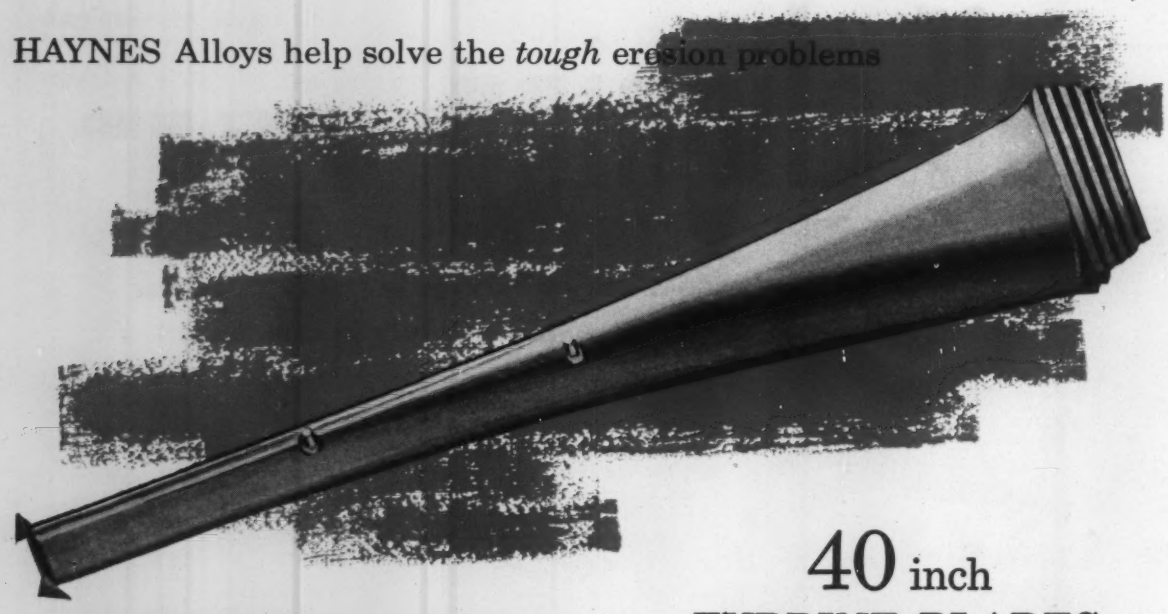
LINK BELT

self-aligning ball and roller bearings

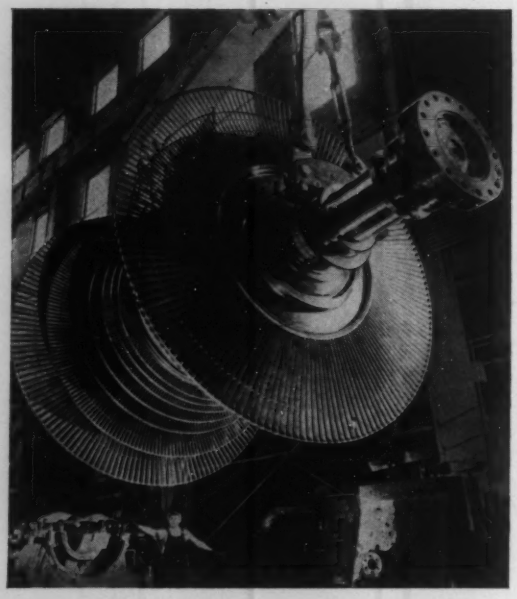
14.441-A

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

HAYNES Alloys help solve the *tough* erosion problems



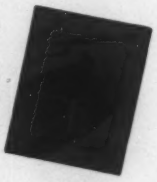
40 inch TURBINE BLADES Protected Against High-Velocity Erosion



...Two rows of 40-inch blades are shown on this double-flow, low-pressure steam turbine spindle. A 27-in. strip of HAYNES STELLITE alloy has been silver-soldered on each blade as protection against high-velocity erosion.

Blading at the cold end of modern condensing-type steam turbines is subjected to severe erosion. Rim speed of some turbines approaches that of a high speed bullet —even small water particles can cause rapid wear on most metal parts at these high velocities.

Yet when the leading edges of these blades are protected with shields of HAYNES STELLITE alloy, they remain in operation for as long as 19 years! This dramatic example of ruggedness is one of the reasons HAYNES cobalt-base alloys are used in many industries to solve abrasion and erosion problems.



For information on long-wearing and erosion resistant alloys, send for our Booklet. Write HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana.

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achieved by preferred orientation of the fibers on the mat.

For high-density parts, the felted material is pressed through rolls or dies. As sheet, it can be worked continuously by felting, rolling, annealing, and sintering.

Cylindrical and convoluted filter elements are made with fiber-resin mixtures. A tubular die filled with fibers is vibrated and thermoplastic resin is added. The mixture is then heated, pulled through the die by vacuum, allowed to cool, and sintered.

Salary Increases for Engineers Taper Off

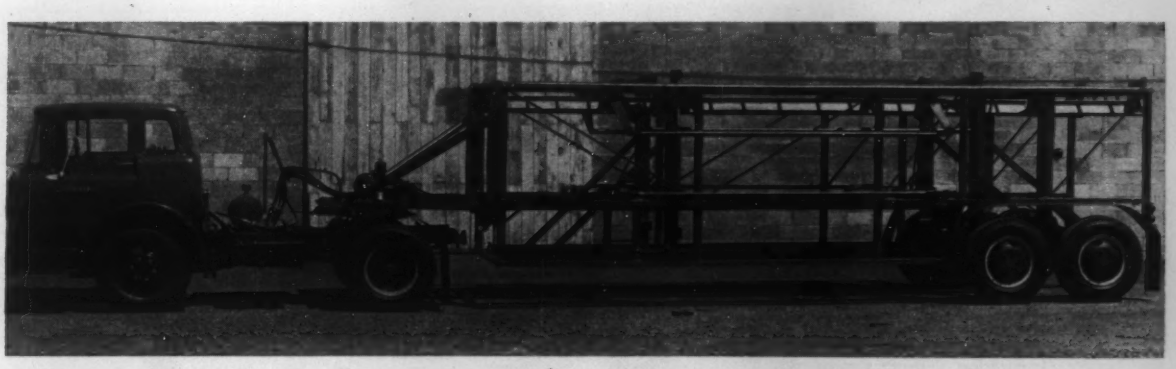
Lower Average Pay Boosts Parallel Management Rise

NEW YORK—Salary levels of engineering and associated personnel in U. S. industry rose an average of 5.9 per cent between 1956 and 1957. According to a survey conducted by the American Management Association's Executive Compensation Service, this increase is appreciably lower than the 8.6 per cent salary rise for the year ended in 1956.

The change may indicate that compensation of engineers, closely paralleling percentage increase of top and middle management compensation, has become relatively uniform of late.

(*Please turn to Page* 28)

DO-IT-YOURSELF GYROCOPTER, produced in kit form by Bensen Aircraft Corp., may become the motorscooter of air travel. Small and light, it can be lifted by one man; carried on the tailgate of a station wagon. Dismantling or assembly requires 20 min. Removable fibreglas cabin is available. Autorotating rotor is not power-driven, making control of the craft more like an airplane than a helicopter, except that it will not spin or stall. Prime mover is an air-cooled, 4-cylinder, 2-cycle engine rated at 40 hp. Pusher propeller is mounted directly to engine shaft. Cruising speed is 60 mph; landing speed, 7 mph.



TRAILER STRADDLES FREIGHT to ease loading and unloading operations. Trailer, built by the Edwards Equipment Co., can pick up preset load in less than 50 sec, unload in less than 15 sec. It hauls fruit in boxes or bins, cattle in a special rack, baled hay, lumber, and canned goods in cases.

U. S. Army Redstone Missile

THE *FORWARD* LOOK

CHRYSLER CORPORATION

BRUNING Reproduction Machines help Chrysler Corporation in Vital Missile Work!

Most of the great work that Chrysler Corporation is doing in missiles must be classified for security reasons. It is no secret, however, that this progressive firm — creators of the advanced "forward look" in automobiles — has played a vital role in the development of the ballistic missile indicated above.

It is no secret, either, that Chrysler Corporation utilizes the outstanding advantages of modern Bruning Copyflex diazotype reproduction machines in this important work. Shown here is the imposing battery of Copyflex machines employed by the Chrysler Corporation. You can see for yourself the famous problem-free installation of Copyflex — no exhaust venting, plumbing, or auxiliary equipment. You can see, too, how Copyflex provides busy operators with such advantages as roomy feed tables, extra-large, convenient stacking trays.

And that's only part of the story. You, like Chrysler Corporation, should be benefiting by such modern Copyflex advantages as greater mechanical speeds, faster return of originals, synchronized exposure and development, automatic separation of originals from exposed prints, automatic stacking, and front-or-rear print delivery.

If you're not getting these important advantages, then every day you delay getting modern Copyflex is costing you time and money. Make the experience of Chrysler Corporation your basis for mailing the coupon below. You'll be glad you did!

Shown here is the impressive battery of Copyflex machines used by Chrysler Corporation for important reproduction operations in vital missile work. Machines need no venting, plumbing, or auxiliary equipment . . . provide Chrysler Corporation with important operating benefits.

Copyflex Gives You All These Advantages

Greater Convenience of Operation! Modern Copyflex gives printing widths up to 54" to simplify feeding of large tracings, facilitate multiple feedings. Such features as extra-large delivery trays, automatic separation, and front-or-rear delivery further speed operator's work.

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Problem-Free Installation and Operation! Clean, quiet, odorless . . . Copyflex requires no vents or plumbing, needs only an electrical connection for operation. Precision-engineered design, including use of selenium rectifiers instead of troublesome vacuum tubes, assures trouble-free operation.

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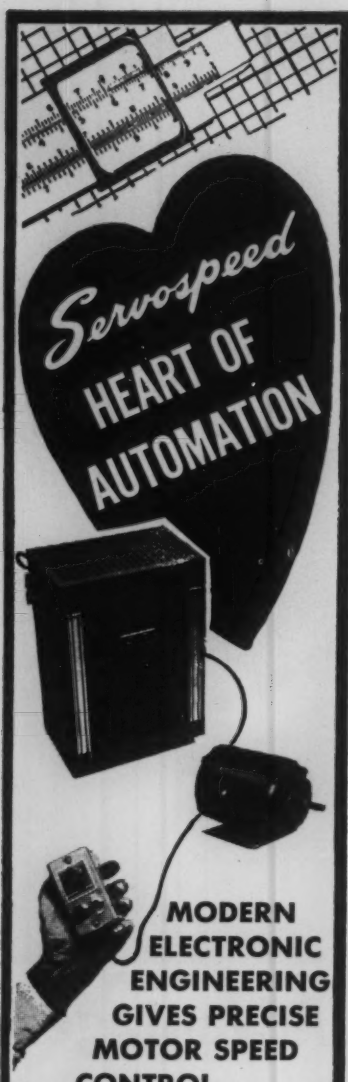

MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
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Circle 417 on Page 19

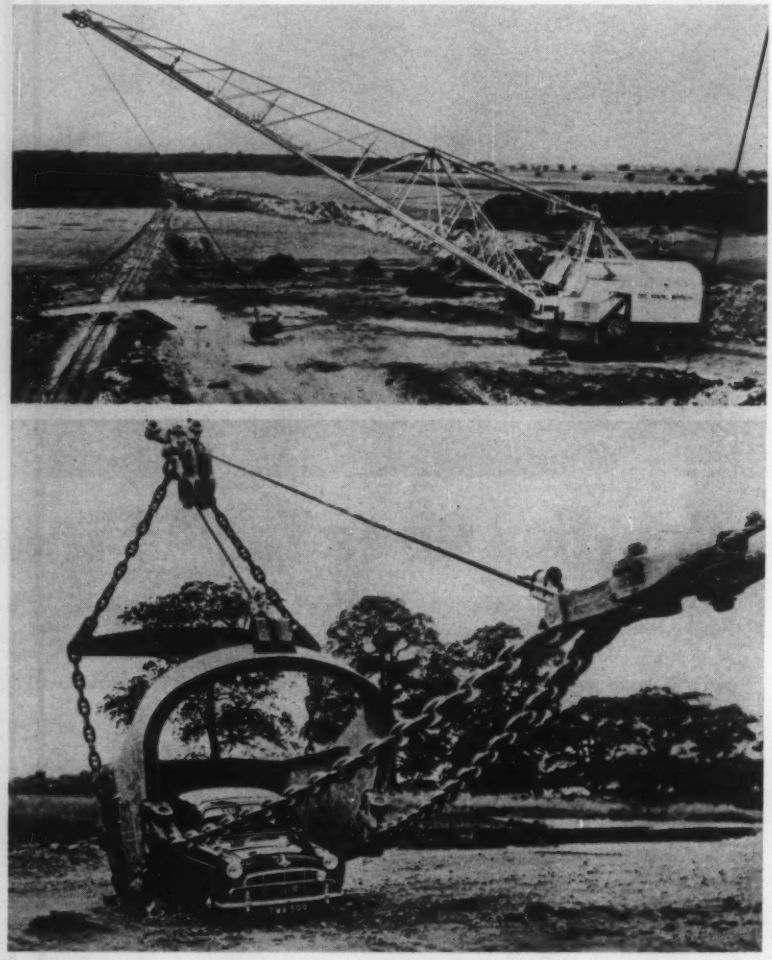
Engineering News Roundup

(*Continued from Page* 25)

The study covered rates and ranges of pay for 33,797 employees engaged in 58 major engineering, scientific, and administrative activities in 263 companies located throughout the U. S. and Canada. This is the first year that Canadian firms have been covered by the survey; hence, the comparisons drawn with the previous year apply only to the U. S.

Percentage salary increases during the year varied for individual fields. The maximum shown was for quality control engineers, who averaged 7.9 per cent in raises. Some electrical and mechanical engineers increased their compensation by an average of 7.5 per cent. The smallest increases shown were for systems and procedures analysts at 3.8 per cent.

Median annual salaries currently paid to engineers in all fields of activity combined range from about $5400 in the lowest or entering category to approximately $13,100



WORLD'S BIGGEST WALKING DRAGLINE mines iron ore in Lincolnshire, England. Built by Ransome & Rapier Ltd., the dragline was transported piecemeal and assembled on the site. The machine, weighing 2000 tons, has a motor enclosure the size of two tennis courts and a jib nearly 300 ft long with head 200 ft high. It can gorge 30 tons in one drag and swing loads at more than 20 mph to a heap. Operated by four or five-man teams on three shifts, it can lift 25,000 tons per week; can take 7-ft strides on two feet, each 48 ft long, 9½ ft wide.

MINIATURIZATION AWARD

MPB

THE AWARD

Miniature Precision Bearings, Inc. cordially invites you to participate in the Annual Miniaturization Award Competition. The Miniaturization Award for 1957 will be presented on March 23, 1958 at the 1st Annual Awards Dinner in New York. The Award will consist of a piece of original sculpture, symbolizing miniaturization, by a leading American artist, which is cast in bronze and inscribed. There will also be Honorable Mentions for additional outstanding contributions.

PURPOSE OF THE AWARD

To increase public knowledge of the importance of miniaturization and to stimulate further activity within industry toward the advancement of the concept of miniaturization.

CRITERIA FOR AWARD

Contributions considered for the Award should have been made in the recent past to be eligible for consideration by the Miniaturization Awards Committee. Details of criteria on which awards will be based can be obtained by writing: Awards Committee, Miniature Precision Bearings, Inc., Precision Park, Keene, N. H.

JUDGING OF ENTRIES

The awards will be judged by an eight-man independent committee comprised of the following individuals: R. L. Goetzenberger, ***Educational Consultant, Minneapolis-Honeywell Regulator Co.*** **/Dr. George H. Lee,** ***Director of Research, Rensselaer Polytechnic Institute*** **/Morton Pavane,** ***Electronics Engineer, Air Research and Development Command*** **/Gerard Piel,** ***Publisher,*** **SCIENTIFIC AMERICAN /Gustave Shapiro,** ***Chief, Engineering Electronics Section, Electricity and Electronics Division, National Bureau of Standards*** **/George F. Sullivan,** ***Editor,*** **THE IRON AGE /Elmer Tangerman,** ***Editor,*** **PRODUCT ENGINEERING /Arthur W. Weber,** ***Vice President, Engineering & Manufacturing, Corning Glass Works*** **/Horace D. Gilbert,** ***President, Miniature Precision Bearings, Inc.***

ENTRIES

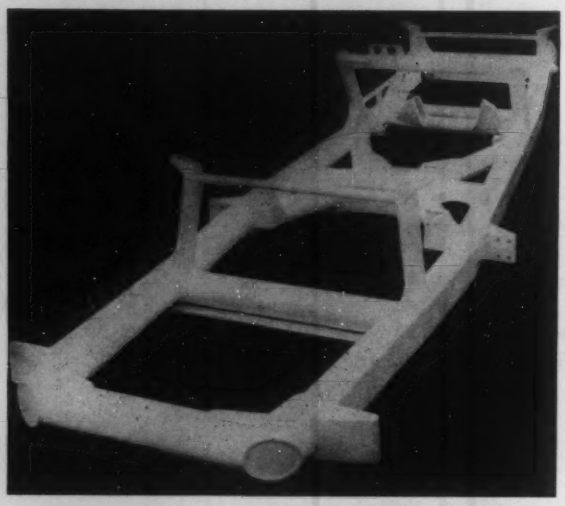
Description of a specific contribution should be made in as complete a form as possible and mailed to the Awards Committee, Miniature Precision Bearings, Inc., Precision Park, Keene, New Hampshire. Samples of the product itself, blueprints or photographs will be helpful. Descriptive information should include some of the design characteristics of the product and the specific problem solved by the miniaturization effort.

DEADLINE

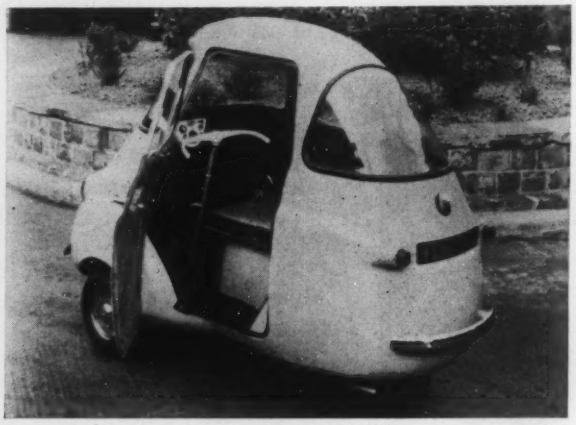
In order to be considered for the 1957 Miniaturization Award, entries must be received by the Awards Committee by January 31, 1958.

MPB

Circle 418 on Page 19



HEAVIEST AUTOMOBILE FRAME in the industry will appear on the new Argonaut—a big, expensive sports roadster going into production (hand assembly) in Cleveland. Frame is 5-in. cold-drawn steel tubing with 3/16-in. walls and 1/4-in. attachments. Coated with white vinyl paint, it weighs 1060 lb, giving the car an unusually low center of gravity. Argonaut has a wheelbase of 127 in.; length of about 215 in. Height to cowl is 37 in.; weight, 4000 lb. Weight distribution is 50-50 providing good roadability and handling. Power steering is not used. Two-place body is aluminum with bucket seats. The engine displaces 392 cu in.; is said to be one of the most powerful V-8s in a production auto. Appearance detail have not been released.



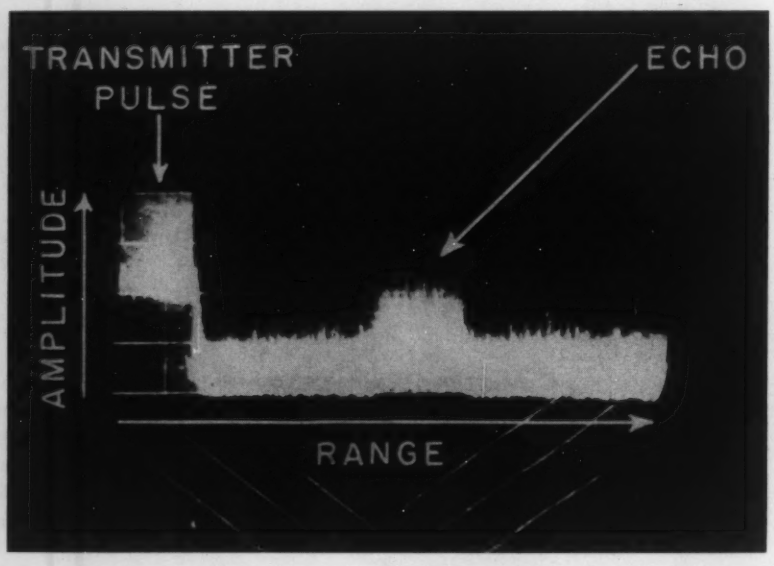
HANDLEBAR STEERING and hydraulic brakes are features of the new English-built Scootacar. The three-wheeled vehicle has space for three passengers; comes equipped with directional signals, windshield wiper, and heater. A 197-cc engine, with four-speed gearbox (optional reverse), provides speeds to 45 mph. Fuel consumption is about 80 mpg. According to Hunslet Engine Co., Locomotive Builders, Scootacar is a new approach to personal transportation, being definitely an enclosed scooter and not a miniature car.

Thirteen most powerful hydraulic turbines in the U. S. will be built by Baldwin-Lima-Hamilton and the Newport News Shipbuilding and Dry Dock Co. for the Lewiston, N. Y., Power Plant. Each turbine is rated at 200,000 hp when operated under a 300-ft head.

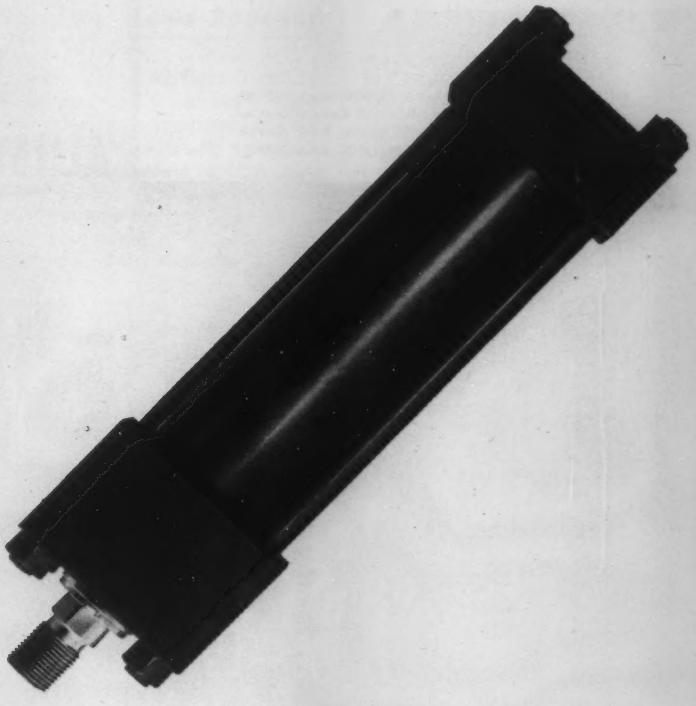
at the highest nonmanagement level. By and large, levels of compensation in Canada are lower than those prevailing in the U. S. For example, Canadian median salaries for engineers of all types fall between $4700 at the lowest level and $10,400 at the highest level.

Classified in the lowest level are engineers with bachelor of science degrees plus up to one year of experience. Classified in the highest level are engineers of long experience responsible for planning, conducting, and supervising assignments involving large and important projects.

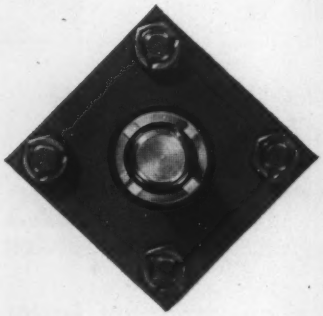
Many individual salaries, of course, vary considerably from the median. For some specific types of engineering jobs, individual salaries are as high as $20,000 a year. Salaries of physicists, mathematicians, and other scientists range from a median of $5400 a year at the beginning level to a median of $14,000 at the highest level.



RADAR ECHO from Sputnik I third-stage rocket, 595 miles away at this "sighting," was recorded at new radar installation. Millstone radar is described on Page 5. Scientists at M.I.T.'s Lincoln Laboratory started sightings of Sputnik I with single radio receiver, expanded their efforts to include observations from four separate locations, have recorded Sputnik signals on both the 20 and 40-mc frequencies.



Why the Leader gives you more!



Because of his laboratories and know-how the leader can give you better design. The leader can afford more efficient tooling and greater quality control.

The leader can give you a better cylinder without a premium price.

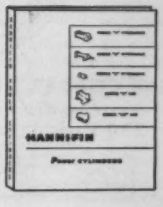
The leader in air and hydraulic cylinders is Hannifin.

AIR AND HYDRAULIC

HANNIFIN

POWER CYLINDERS

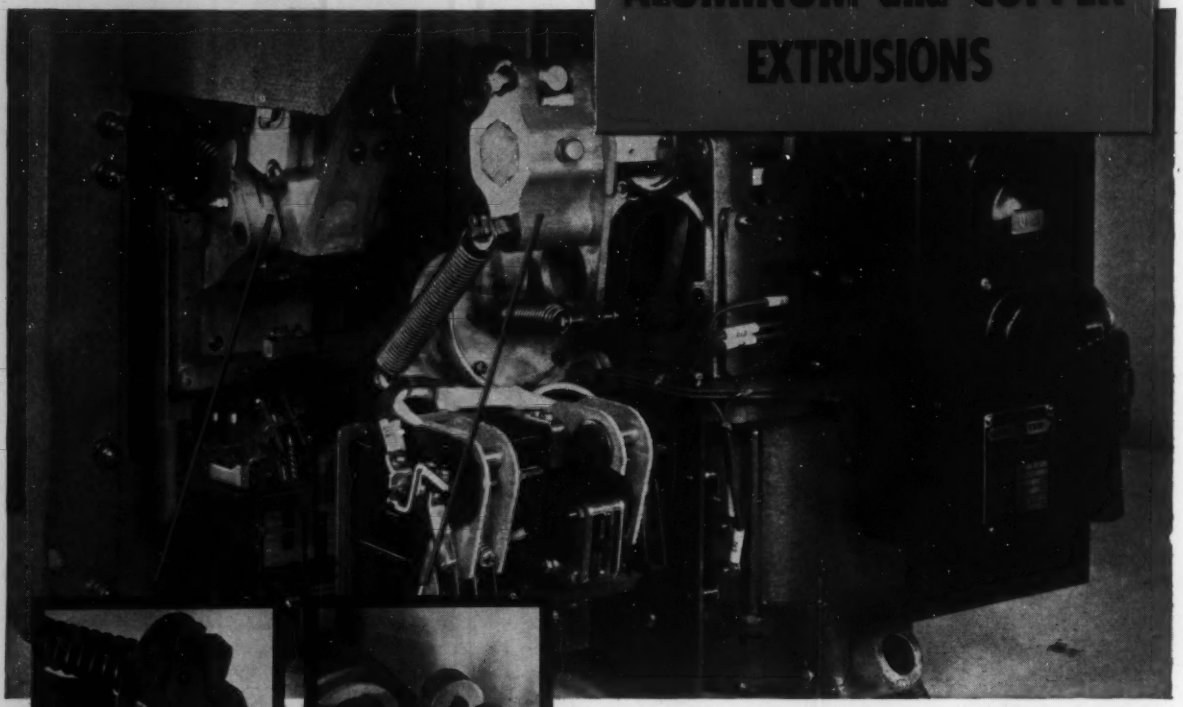
Write for your copy of this new Hannifin Cylinder File—complete, easy-to-use, easy-to-order-from information on five lines of Hannifin cylinders. Hannifin Company, 515 South Wolf Road, Des Plaines, Illinois.



Circle 419 on Page 19

REVERE
ALUMINUM and COPPER EXTRUSIONS

I-T-E CIRCUIT BREAKER—KD (3,000 amp. rating) showing progressive assembly with Revere Copper and Aluminum Extrusions in place. I-T-E Circuit Breaker—KE is same type with 4,000 amp. rating.



COPPER
for conductivity

ALUMINUM
for economy

—form a Money-Saving team in latest

I-T-E CIRCUIT BREAKERS

Revere T. A. Service an Important Factor in Ultimate Design of Parts

The larger of the two extruded and drawn copper shapes shown at extreme left started out on the drawing board as two pieces. It was thought that a single shape of this size could not be made satisfactorily. At this point, I-T-E Engineers got together with Revere's T. A. (Technical Advisory) Service and threshed things over. The final result is the one-piece extrusion shown and a reduction in machining time.

Aluminum was selected for the other extrusion shown because I-T-E found that it cost less per pound of metal and had a higher strength ratio when compared to a casting. Also, space was a factor. In all, Revere supplies 5 copper and 2 aluminum extrusions for KD and KE type I-T-E Circuit Breakers. All were designed to fit specific requirements of I-T-E Engineers. Where it could be used satisfactorily, aluminum was applied because of economy, while current carrying members called for copper.

This is still another example of Revere supplying the metal that will do the best job and with the greatest economy . . . be it aluminum, copper or any one of their alloys. So, with new things happening all the time in non-ferrous metals it can pay you to keep in close touch with Revere.

COPPER ★ BRASS ★ 18 01 ★ REVERE ★ ALUMINUM

REVERE COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N. Y.

Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

Circle 420 on Page 19

BIG BIT for the Army will be used for fast construction of field fortifications, shallow wells, and waste-disposal pits. Mounted on a standard 5-ton truck, the mobile earth-auger will dig holes up to 6 ft in diameter and 22 ft deep in practically any type of earth strata. Boom is hydraulically actuated. Power for the digging unit is supplied by 127-hp gasoline engine. Standard attachments include various sized auger bits, core barrels for drilling in rock, and provision for using air, water, and calyx drilling attachments. Now under test at the Army Engineer Research & Development Laboratories, unit was developed by H. B. Williams Mfg. Co.

Microminiaturization Applied to Transistors

Wee Transistors Are Formed By Vapor Deposit, Film

WASHINGTON — Many electronic items may be made smaller through a new technique for reducing the size of transistors. Army research scientists call this new method the "missing link" in their continuing effort to cut down both bulk and weight of Ordnance electronic devices. They foresee military equipment reduced to one-tenth of its present size in some items, and expect their printed-circuit transistor to be equally valuable to civilian industry.

The process was invented by two civil service employees of the Army's Ordnance Laboratories in Washington, Dr. J. W. Lathrop and Mr. James R. Nall. The new process seems ideally suited to automation and mass production of transistor systems at low cost. Reliability and resistance to shock and vibration reportedly will be

(Please turn to Page 36)

Circle 421 on Page 19

CLAYMONT your for Fabricated

Claymont's new Fabrication Shop provides more than 100,000 square feet of floor space containing a complete range of efficient production line layout and modern shipping facilities.

You'll save time and money by letting Claymont perform difficult, time-consuming machining and fabricating operations on your steel plate before it's delivered to you.

Claymont Has The Facilities... Our new Fabrications Shop is completely equipped to perform all these steel plate operations:

WELDING · SHEARING · PUNCHING · MILLING · PAINTING BENDING · CUTTING · BORING · GRINDING · CHIPPING · EDGE PREPARATION · ROLLING · PRESSING · DRILLING · SHAPING PRIMING · SHOT BLASTING

Your Supply Of Steel Is Assured... Claymont's is a completely-integrated operation. From the selection of raw materials through blast furnace, open hearth, rolling mill to steel plate fabrications... every operation is performed within the company.

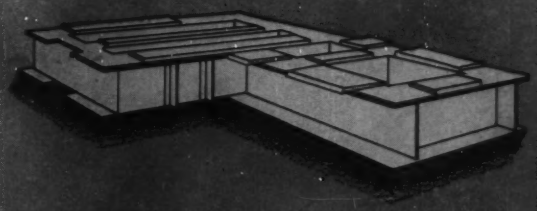
You Get Uniform Quality In Accordance With Your Needs ... Because Claymont's operations are fully integrated, we are able to exercise rigid quality controls throughout every single stage of production and fabrication to assure that customer specifications will be met.

Bring your steel parts problems to Claymont. For complete information contact the sales office nearest you.

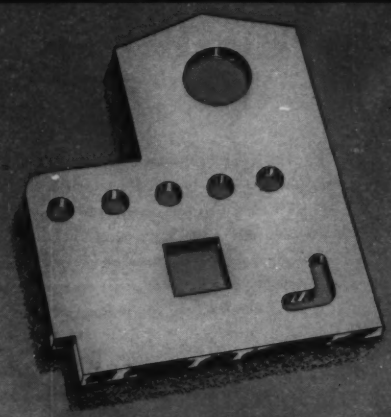
4936

dependable source Steel Parts

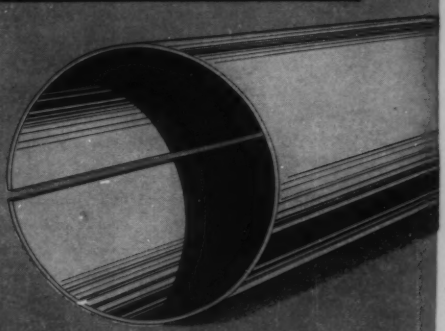
Production Weldments—Many production component parts for which castings are presently being used can be safely and profitably replaced by weldments. The advantages: cost savings plus reduction in weight with no loss in strength. Claymont is completely equipped to produce weldments in many sizes and shapes, and from a wide variety of steels.



Flame-Cut Patterns—Claymont has multiple-torch travagraphs for producing large quantities of irregular shapes that exceed the gage or size limitations of blanking presses; and single-torch, semi-automatic radiagraphs for cutting straight cuts and simple patterns, circles and smaller-quantity jobs. A special type of radiagraph is used to prepare edges prior to welding.



Heavy-Duty Plate Forming—Claymont's heavy-duty mechanical pressing, bending, and shaping equipment is capable of a wide variety of forming operations on heavy steel plate.



OTHER CLAYMONT PRODUCTS

Alloy Steel Plates · Large Diameter Welded Steel Pipe
High Strength Low Alloy Steel Plates · Stainless-Clad Plates
Manhole Fittings and Covers · Flanged and Dished Heads
CF&I Lectro-Clad Nickel Plated Steel Plates

CF&I

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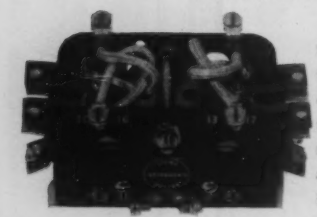
San Francisco • San Leandro • Seattle • Spokane • Tulsa • Wichita
CF&I OFFICES IN CANADA: Montreal • Toronto • **CANADIAN REPRESENTATIVES AT:** Calgary • Edmonton • Vancouver • Winnipeg

Circle 422 on Page 19

no beeps
...just clicks

This is probably about the most groundborne relay ever built by Sigma. Since its leviathan specifications include a brutish size of $3\frac{1}{2}$" x $2\frac{9}{16}$" x $2\frac{9}{32}$" and a weight that can reach $\frac{5}{8}$ of a pound (even bigger and heavier when hermetically sealed), it's exceedingly doubtful that it will ever fly, orbitally or otherwise. Since *that* kind of quick fame is out of the question, the "61" should be able to do some other — though less timely — sort of job. It can, and here's where you product designers can start paying close attention.

The 61 is a polarized DC power contactor, with four separate heavy-duty contact circuits (DPDT only) for switching up to 20-ampere resistive loads in response to momentary ¼ to ½ watt signals. Two switching forms are available: Form Z, magnetic latch-in, single or dual coils, and Form Y, magnetically biased, single coil. For special jobs, center-stable 61's can also be built (Form X). Since the Form Z types latch firmly in either of two positions by magnetic means, there are no mechanical wearing surfaces; the one part that does move uses miniature ball bearing pivots.



POLARIZED LATCHING CONTACTOR

Some of the places we'd expect the 61 to be particularly useful include machine tool control panels, battery-powered control systems, and other equipment where big fat loads must be dependably switched by comparatively meager signals, in the presence of contact-disturbing shakes, shocks and rumblings. Space and money can also sometimes be saved by a 61, in replacing a pilot and slave relay combination where 225-450 mw. signals have to control 1 to 2 kw. loads.

Series 61 relays are quite easy to order, once you master Sigma's international, all-encompassing system of code designation (readable east to west, north to south, without binoculars). Example: 61FZ2A2B — 200 — GD SC = an unenclosed latching DPDT 61 with 200-ohm dual coils and silver alloy contacts. Bulletin, on request, explains all this and more.

SIGMA INSTRUMENTS, INC.
89 Pearl Street, South Braintree 85, Massachusetts

News Roundup

(*Continued from Page 33*)

increased.

The new transistor method is said to start with a tiny wafer of the metal germanium. Photosensitive film provides precise masks on a ceramic plate for positioning the pin-point electrodes of the transistor. The electrodes are formed by vapor deposit. The process cuts the size of transistors to about 1/20 in. wide and 0.01 in. high.

CORROSION PREVENTION using an automatic electrical system, has been developed by Charles Englehard Inc. A ship's hull corrodes due to variation in composition of the steel—causing it to act like two different metals. Some areas become anodic and corrode, while other areas serve as cathodes. In Englehard's system, thin platinum discs are mounted on the hull, insulated by an 8-ft square neoprene blanket. Supplied with current from the ship's generators, they make the entire hull cathodic. This overcomes the galvanic electrical flow between different parts of the hull; eliminates corrosion. Voltage supply to anodes is automatically monitored.

Transducer Error Equals Baseball at Three Miles

NEW YORK — An electromagnetic, angle transducer, called the vernier resolver, has resolution of better than ±3 sec of arc. This is about the same angle as that subtended by a baseball at three miles. The

resolver, developed by Bell Telephone Laboratories under an Air Force contract, has potentially wide applications for visual and automatic angle reading systems.

It has been used in an "angle encoder" which converts a shaft angle to a numerical representation acceptable to a digital computer. The standard deviation of the error of this complete encoder is less than 10 sec of arc.

The vernier resolver is a reluctance type, variable coupling transformer. In its present design, two output voltages vary in amplitude as the sine and cosine of 27 times the angle through which the rotor is turned. Thus, the equivalent of a standard resolver driven by a 27:1 gear train is obtained.

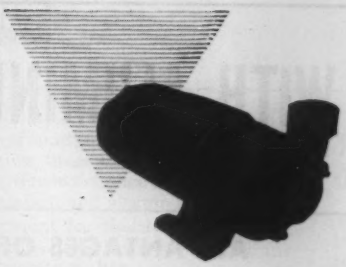
Business Failures Lag Growing Total of Firms

NEW YORK—Business failures have not kept pace with the increasing total of business firms. According to the Business Economics Div. of Dun & Bradstreet Inc., more than half of the failures occur in businesses that have been in existence for five years or less. The proportion of "younger" failures has been declining steadily in the past 10 years, from 77.6 down to 58.6 per cent. However, the toll among businesses, ten years or older, has increased almost steadily in the same period, from 9.1 to 18.3 per cent.

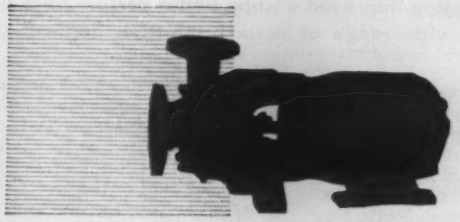
In manufacturing per 10,000 concerns, there were 143 failures in electrical machinery, 116 in transportation equipment and 69 in machinery. A breakdown of failure causes for all business shows "inadequate sales" responsible for 47.9 per cent of losses, "competitive weakness" as next most prominent fault, 21.2 per cent.

Stone, clay, and glass manufacturers showed lowest rate of failures with only 30 per 10,000 concerns. By states, the highest failure rates per 10,000 concerns were Nevada, 141.8; California, 135.0; New York, 106.5. Lowest failure rates were in South Dakota, 10.2,

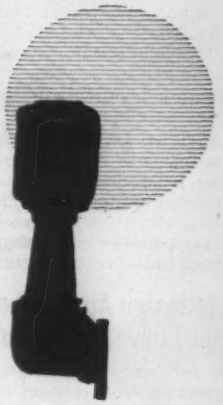
(*Please turn to Page* 40)



get design flexibility



with I-R motorpumps



Simplify your problem of incorporating dependable pumping by selecting from Ingersoll-Rand's extensive line. No other manufacturer gives you a choice of so many types and sizes . . . no other pumps offer the same proven reliability and efficiency.

Motorpumps are available for sidewall, immersion or foot mounting. Get complete information now by writing for descriptive literature.

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DESIGNING WITH ALUMINUM

NO. 26

This is one of a series of information sheets that discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., Department PD-1, 919 No. Michigan Ave., Chicago 11, Ill.

ADVANTAGES OF ALUMINUM FOIL STRIP FOR ELECTRICAL WINDINGS

Conversions from round copper wire to aluminum interleaved strip windings are bringing improved design, better performance and lower costs to a wide range of mass production applications.

ALUMINUM RIBBON, interleaved with insulation material, may be used successfully in place of copper in such applications as: transformers for radio and television; motor starters and aircraft accessories; field and rotor windings for motors and generators; coils for solenoids, relays and ignition devices; chokes, filters and a vast range of similar electromechanisms and electronic devices.

Conversion to Foil Strip Offers Design Advantages

Although the design of any electromagnetic unit depends upon its specific application requirements, aluminum ribbon conductor offers several advantages to *all applications* converted from round copper wire:

1. *Reduction in void space often allows equivalent cross-section size.* Whereas round copper wires leave unfilled spaces between strands, the flat aluminum ribbons lie neatly together in a compact mass free of voids. This can often allow equivalent winding cross-section size. Where cooling ducts and layer insulation are used, the aluminum ribbon and interleaving insulation will almost always fit the same winding gap as copper.
2. *Excellent heat dissipation reduces operating temperature.* Aluminum conducts heat better than any insulation or impregnating material. A ribbon-wound coil has substantially the same temperature throughout a layer of conductor because each layer is a solid conductor and dissipates heat to the outside. Absence of voids eliminates formation of local "hot spots"—has reduced temperature as much as 100°F. This control of temperature normally allows a reduced aluminum cross-section for equal current carrying capacity.
3. *Lower space factor helps reduce cost and weight.* Because ribbon wound coils generally operate at temperatures 20 or more degrees (F.) lower than wire wound coils, it is possible to reduce the 1.64:1 aluminum-to-copper area ratio that is theoretically necessary. In actual use, area factors are about 1.5 and occasionally have been as low as 1.25, making possible weight reductions of over 50%... with cost savings of 30 to 40% for copper wire conversions in sizes #24 or larger.
4. *Manufacturing method reduces problem of conductor tensile strength.* Because wire-drawing tensions are absent in manufacturing the slit aluminum ribbons, and because aluminum strip has better heat dissipation and lowers coil temperatures, comparative conductor strength has little significance. Aluminum ribbon conductor is readily available and readily adaptable to high production techniques.
5. *Effective joining methods available at low cost.* A wide variety of joining techniques and equipment—all proved in thousands of high-production electrical devices—offer economy equal or better than copper for both initial cost and maintenance.

Two Design Approaches Meet Conversion Problem

The fundamental design problem in converting from copper to aluminum conductor is, of course, to provide for and accommodate the additional coil cross-section needed for equal conductance and reactance, and at the same time provide equal dissipation of heat. Two basic approaches may be taken to this problem.

First, the conductor cross-section may simply be increased by the appropriate factor (1.5) to give the same ampere turns and resistance; or second, the wiring area may be changed to allow a better ratio of conductor to insulation where space is critical or the coil may be split and connected in series to further help this conductor to insulation ratio.

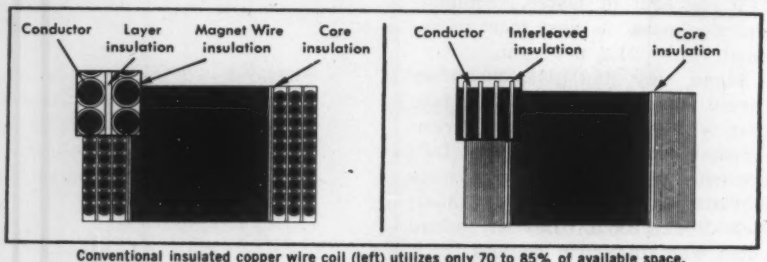
Designing for a compromise between these two approaches is favored by the physical shape of aluminum strip conductor, and allows the designer to make use of the advantages of both approaches. The aluminum ribbons are produced by slitting from foil, which may be mill-rolled to any requested thickness, and thus are available in any desired combination of gauge and width, unrestricted to standard gauge sizes. And—to the designer's advantage—the aluminum conductor proportions may be exactly determined *by the rectangular geometry* of the wiring cross-section.

Elimination of the voids between circular conductor sections together with the better dissipation of heat due to this design results in working temperatures normally about 20°F. cooler than in round wire. Some ribbon wound coils have reduced "hot spot" temperatures by as much as 100°F., and have accepted without damage excess loadings that have destroyed electromagnetically-equivalent copper wire wound coils.

When aluminum ribbon conductor is substituted for copper wire to give equal current carrying capacity and equivalent resistance, the aluminum conductor assembly is little or no larger and *sometimes smaller*—than its copper prototype.

Insulation Need Not Have High Dielectric Strength

Because the potential between successive wraps is usually low, the insulation materials between layers normally does not require high dielectric



Conventional insulated copper wire coil (left) utilizes only 70 to 85% of available space. Aluminum interleaved strip conductor coil (right) utilizes up to 97% of overall space.

strength. Condenser paper 0.00025" in thickness may be used in many applications where space is highly critical.

"Mylar"* and "Teflon"* plastics have excellent dielectric, tensile and scuffing strength. They are available in gauges down to 0.00025" and accept, without aging, higher temperatures than paper. The higher cost of "Mylar" for Class B insulation, and the still higher cost of "Teflon" for Class H insulation are justified for conversion of high operating temperature coils.

Fixed coatings such as resins and enamels are efficient and eliminate separate interleaving. Although they are not commercially available at this time, should they become more readily available in the future, this factor would further reduce material cost.

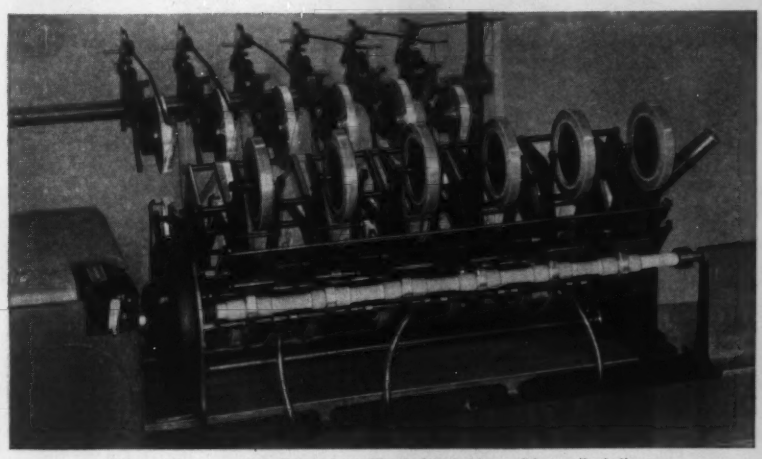
Anodized conductor similarly needs no separate insulation, resists temperatures up to 750°F., and eliminates the need for separate interleaving materials. Extreme care is necessary to prevent edge crazing of the anodic coating during the winding operations. The anodic coating is inherently porous and requires sealers against moisture. Such sealers are presently limited to a maximum temperature of about 400°F.

The strip insulation lowest in weight and cost is condenser tissue of suitable gauge. The paper is limited by a tendency to become brittle after lengthy exposure to temperatures above 250°F., but otherwise is an excellent general purpose insulator. Because of its natural porosity, it may be readily impregnated with resin sealers for protection against moisture, or with sealer-adhesive materials to bind the interleaved coil into an integral unit.

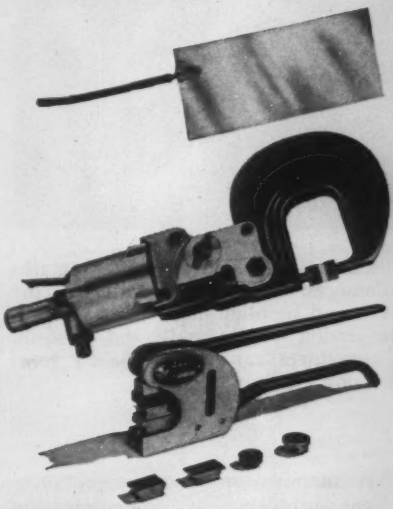
Most of the existing machinery for handling single-wound, heavier size conductors can be adapted readily to the use of aluminum ribbon by adding little more than an unwinding reel, a suitable tension device and guides for the insulation and aluminum strip.

Equipment for multiple winding of smaller coils often is too specialized for easy adaptation, but usually may be converted by more detailed alterations. In present practice, both conductor ribbons and insulation strips are wound from reels of pre-slit material.

*Dupont trade names.



Modern foil coil machine designed specifically for aluminum ribbon coil windings. (Universal Winding Company, Providence, R. I.)



Above: Tinned copper wire pressure welded to aluminum foil. **Below:** Koldweld tools made by Utica Drop Forge and Tool Division of Kelsey-Hayes Company.

Tested Joining Methods Offer Economy, Versatility

The joining of round, flat, and stranded leads of aluminum or copper to ribbon conductors of aluminum has been accomplished in a variety of ways. Soldering or brazing of leads and terminals may be accomplished by use of suitable aluminum fluxes and solders, by ultrasonic soldering techniques, or by the use of fiber-glass brushing in conjunction with recommended aluminum solders on the heavier gauge materials.

Cold or hot pressure-welding is an extremely economical method by which the metals are pressed into plastic-flow merging of surfaces to give a true weld. Flash welding and inert arc welding also produce good welded joints. Standard crimping procedures have been used effectively although the ribbon conductor shape also permits punching to receive wide flange connecting parts without need for crimping.

Where dissimilar metal joints are used and are susceptible to high humidity conditions, suitable resin sealers may be applied at the joint to minimize the possibility of galvanic corrosion.

The operating and cost efficiencies of aluminum strip conductor are most marked when replacing copper wire of #24 AWG or larger, but savings have been realized by conversions through #30 gauge. Economies in conductor cost, including insulation, have been recorded from 30 to 40%.

Kaiser Aluminum does not manufacture electromagnetic coils or insulation materials, but has wide availabilities of aluminum ribbon conductor and a special technical staff to assist coil manufacturers and users in all details relating to the use of its conductor materials in their products. Inquiries for such assistance are welcomed and sample coils can be fabricated to customer specifications for their evaluation in possible conversions.

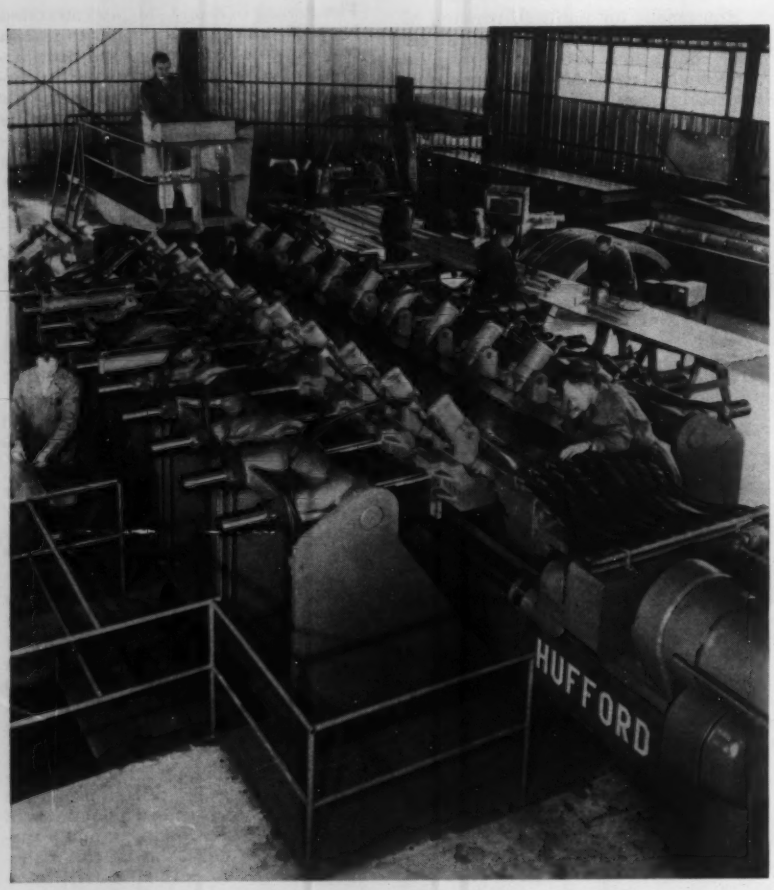
For immediate attention to your request for this technical service or samples, or for more detailed information, contact the Kaiser Aluminum sales office listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 22, Calif.

see our catalog in
PRODUCT DESIGN FILE
or write for copy

KAISER ALUMINUM
THE BRIGHT STAR OF METALS

(*Continued from Page 37*)

Arkansas, 11.0; North Dakota, 11.3. Failure statistics given include only those concerns which go out of business with loss to creditors.



BIAXIAL STRETCH FORMER handles sheets in which the stiffening ribs have been extruded, and holds close tolerances. Built by Hufford Corp., the machine forms sheet sizes up to 5 x 24 ft and supplies ample force to form 2014-T4 aluminum up to 14 sq in. cross-section longitudinally and 46 sq in. cross-section transversely. Transverse curvatures can be developed from straight to a 30-in. radius. Grips work along all four sides.

Suggest Satellite Be Used To Bounce Phone Signals

Satellite Bounce Easier Than Crossing Mountains

NUTLEY, N. J.—Long-distance telephone conversations of the future may be bounced off earth satellites to provide communication with all parts of the globe, a radio scientist predicted recently. According to Richard E. Gray of Federal Telecommunication Laboratories, "present problems of communicating over mountains or oceans could be bypassed by aiming radio signals at the smooth 'skin' of a satellite."

The envisioned technique would utilize microwave equipment now available. Directional antennas would focus the microwave beam directly at the satellite. Radio impulses would be reflected in all directions, but a large percentage would blanket the earth, where

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2-WAY
Normally Closed and Normally Open
Pipe Sizes: ⅛"—2"
Pressures: to 1500 P.S.I.
Voltages: 115-230-460/60
Solenoids: General Purpose, Watertight, Explosion Proof
Services: Air, Water, Oil, Gas, Steam

3-WAY
Normally Closed and Normally Open
Pipe Sizes: ⅛"—½"
Pressures: to 600 P.S.I.
Voltages: 115-230-460/60
Solenoids: General Purpose, Watertight, Explosion Proof
Services: Air, Water, Oil, Gas, Steam

4-WAY
Pipe Sizes: ¼"—1"
Pressures: to 300 P.S.I.
Voltages: 115-230-460/60
Solenoids: General Purpose and Explosion Proof
Services: Air, Water, Oil

HAND RESET
2-WAY
Pipe Sizes: ½"—1"
Pressures: to 250 P.S.I.
Voltages: 115/60
Solenoids: General Purpose
Services: Air, Water, Oil, Gas

3-WAY
Pipe Size: ⅜"
Pressures: to 250 P.S.I.
Voltages: 115/60
Solenoids: General Purpose and Explosion Proof
Services: Air, Water, Oil, Gas

STRAINERS AND FILTERS
Pipe Sizes: ⅛"—3"
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Special purpose solenoid valves and accessories are also stocked.

All sizes and types of ASCO Solenoid Valves now carried in stock by our warehouse in Los Angeles, and by stocking distributors in all principal cities.

Send for ASCO Solenoid Valve Stock List and Selection Guide.

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54-A Hanover Road, Florham Park, New Jersey
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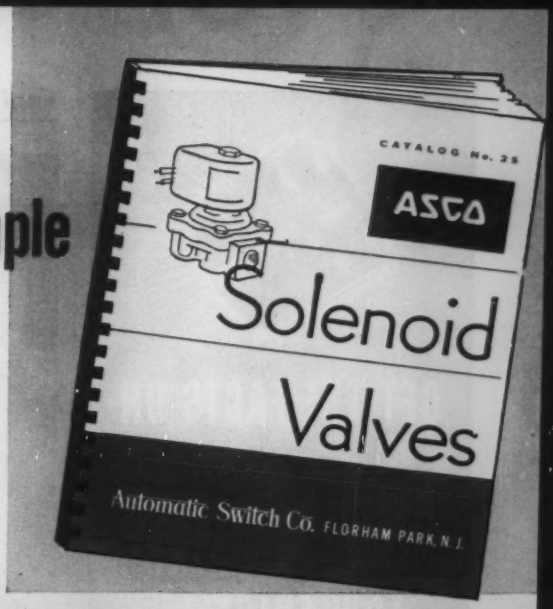
Circle 426 on Page 19

ASCO makes Solenoid Valve selection simple

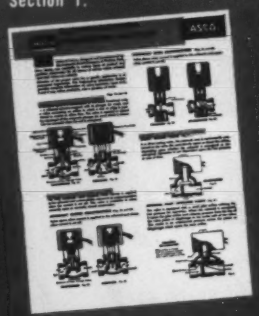


Comprehensive Design Engineering Data Now Available
Keys Proper Solenoid Valve to Application

Specifically designed to make the selection of solenoid valves simple, the ASCO Valve Catalog gives you the most comprehensive engineering data available to aid you in your solenoid valve selection.

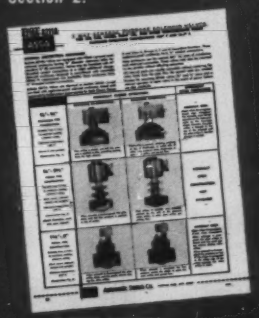
Here are 114 pages of up-to-date valve information. These pages incorporate detailed engineering sections. Finding the proper valve for your particular application is made easy by a simple *master index* which leads you to a *separator* where you will find all the valves of the type you require. Each *separator* has a more detailed *index* which will enable you to turn right to the *valve bulletin* needed to meet your particular requirements.

Section 1.



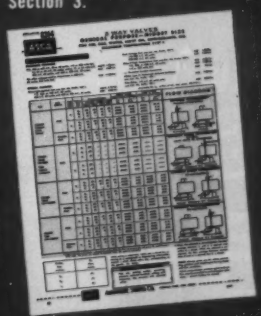
GENERAL ENGINEERING INFORMATION
Expanded engineering data with diagrams, gives valve construction, operating principles, features. With nomographs using Cv ratings for valve sizing.

Section 2.



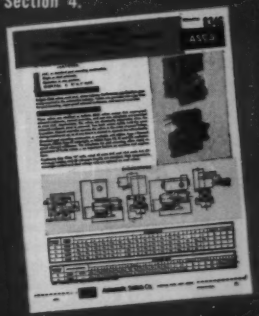
2-WAY VALVES
Covers all 2-way valves of the fully automatic type for a wide range of pipe sizes and pressures.

Section 3.



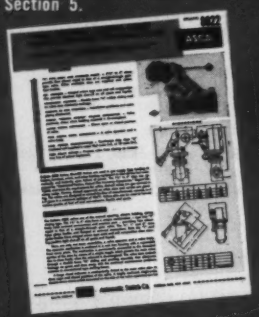
3-WAY VALVES
Detailed information on fully automatic valves for pilot control of diaphragms or cylinders, or for diverting flow in pipelines.

Section 4.



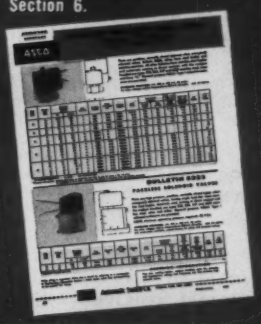
4-WAY VALVES
Fully automatic types covered. Both single and dual solenoid construction for general purpose and J. I. C. requirements.

Section 5.



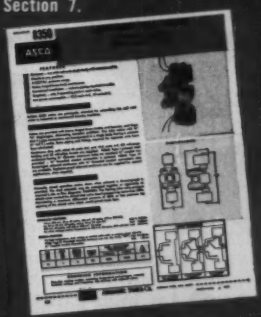
MANUAL RESET VALVES
2 and 3-way solenoid valves for safety shut-off applications.

Section 6.



CORROSION RESISTANT VALVES
Includes 2 and 3-way solenoid valves for handling corrosive gases and liquids. Section incorporates a selection guide chart.

Section 7.



SPECIAL PURPOSE VALVES AND ACCESSORIES
Special purpose equipment: waterproof and explosion proof solenoids, laundry valves, cylinders, etc.

Section 8.

NUCLEAR VALVE DATA
Shows ASCO specialized solenoid valve designs for nuclear, guided missile, Navy and dispensing applications.

You may order the complete catalog or individual sections or bulletins. You will find easy to use return reply cards in each catalog for ordering additional literature. Also available is the Electromagnetic Control Master Catalog 57-S or any one of the six sectional Catalogs covering Automatic Transfer Switches, Remote Control Switches, Contactors, Relays, Solenoids or Electric Plant Controls.

Any of these important engineering reference aids may be obtained by writing Automatic Switch Company — *on company letterhead only please.*

Automatic Switch Co.
54-A Hanover Road, Florham Park, New Jersey
FRontier 7-4600

ASCO

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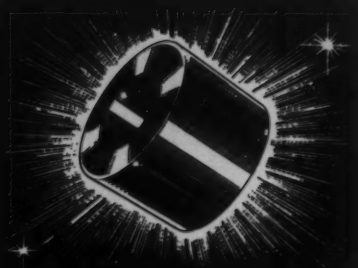

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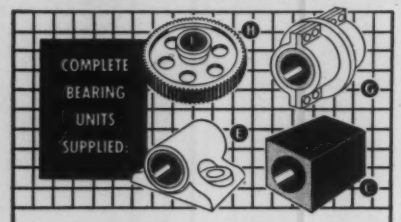

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GRAPHALLOY has high-performance electrical properties: *low electrical noise, low and constant contact drop, high current density, minimum wear!*

Brush Holders and Assemblies, Coin Silver Slip Rings and Assemblies available.

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Circle 427 on Page 19

UNITED ENGINEERING CENTER, to be erected on United Nations Plaza between 47th and 48th Streets, New York, will serve as headquarters of 16 national engineering societies with total membership of about 250,000. Planned $10-million, 20-story tower will include library and exhibition space. In all, there will be about 250,000 sq ft of floor space. Societies and other organizations whose headquarters will be in the new building are:

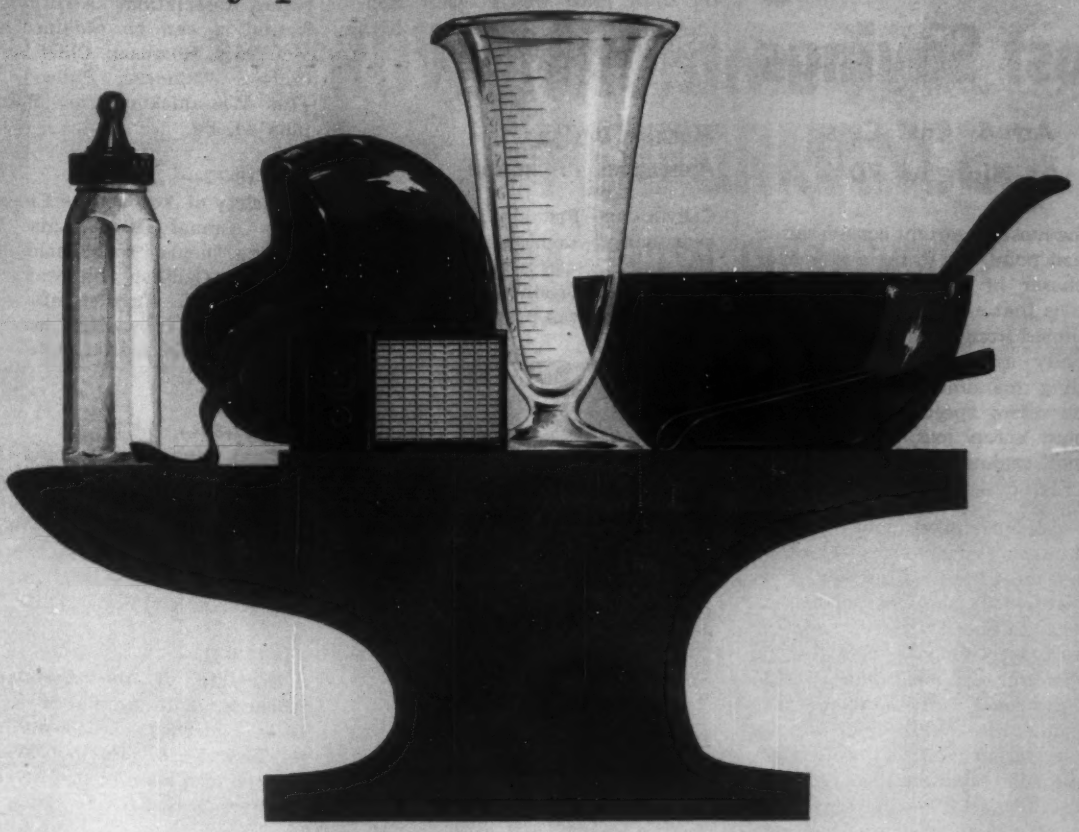
Amer. Inst. of Chem. Engrs.
Amer. Inst. of Consulting Engrs.
Amer. Inst. of Elec. Engrs.
Amer. Inst. of Ind. Engrs.
Amer. Inst. of Mining, Met., and Pet. Engrs.
Amer. Rocket Soc.
Amer. Soc. of Civil Engrs.
Amer. Soc. of Heat. & Air-Cond. Engrs.
Amer. Soc. of Mech. Engrs.
Amer. Soc. of Refrigerating Engrs.
Amer. Standards Assn.
Amer. Water Works Assn.
Amer. Welding Soc.
Electrochemical Soc.
Engrg. Foundation
Engrg. Index
Engrs'. Council for Professional Development
Illum. Engrg. Soc.
Soc. of Motion Picture and TV Engrs.
Soc. of Naval Arch. & Mar. Engrs.
Welding Research Council

high-gain antennas would receive them. To facilitate focusing the antennas, the satellite would have to rotate at the same speed as the earth.

Gray and another FTL scientist, Rodney D. Chipp, also described the world's first commercial "over-the-horizon" microwave radio links, inaugurated this year in the Caribbean and Mediterranean areas. Included was a discussion of the "over-the-horizon" link that made possible television's longest hop—185 miles from Fla. to Cuba. This "electronic bridge" carries more than 120 telephone channels as well as television.

Aerial Jeeps were subjects of a picture item in Engineering News Roundup for September 5. The caption announced that one of three companies awarded contracts

For sturdy plastics . . .



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GREX, new high density polyethylene, offers a combination of vastly improved properties that broadens sales potential for plastic fabricators and their customers as well.

For example, GREX brings to industrial moldings impact and tensile strength far superior to many costlier molding materials. GREX-made hospital items that require sterilization and chemical cleaning, won't wilt, stay like new. In refrigerator containers and trays, GREX stays brittle-free, demonstrating resistance to extreme cold. GREX makes top-grade electrical insulation. Film made from GREX features good 'slip' and is suitable for high speed packaging. It is easily heat sealed and is an effective moisture barrier.

Toughness, durability, boilability—learn how these and other improved properties of GREX can help *you* turn out better made, faster selling plastics! Mail the coupon today!

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COMPANY.....

ADDRESS.....

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(Advertisement)

Cold Heading Cost Savings

Actual Cost Cuts As High As 70%

The most important consideration we can point out to the designer or purchaser of fasteners and small parts is that any part which can be machined from rod stock is also potentially available from the cold heading manufacturer. This technique offers speed of production, without scrap loss, plus superior strength and appearance for low cost and high design efficiency.

The designer need not be restricted to standard fastener sizes when they do not meet the requirements of his application. It is often much less expensive to specify a rivet, nail or screw to meet the task exactly as the application requires, than it is to compromise its function for the sake of "standards." While there is nothing mysterious about the cold heading process, experience has proved it to be of inestimable value for getting maximum quality and output at a minimum cost. While the really spectacular advantages in cost show up in runs of several thousand pieces, we are also able to take care of short run requirements. We welcome and expect manufacturers to come to us for advice and assistance concerning their fastener problems.

Given complete specifications, including a drawing and an idea of the application, we can quickly tell you whether or not it will be advantageous to have your fastener or part JOB-DESIGNED by HASSALL. The remaining important aspect of our service to you is the ability to get into production quickly and make prompt shipment.

Write for a copy of our new booklet, "What the Designer Should Know about Cold Heading".

John Hassall, Inc.

P. O. Box 2197

Westbury, Long Island, N. Y.

Circle 429 on Page 19

for these craft was Piasecki Helicopter Corp. It should have been Piasecki Aircraft Corp.

Machine Design Announces Promotion

CLEVELAND—Frank M. Butrick has been named an associate editor of MACHINE DESIGN. He has been an assistant editor since August, 1956. Mr. Butrick was previously a proc-

Frank M. Butrick

ess engineer at Lobdell-Emery Mfg. Co., Alma, Mich. He is a member of the American Society of Tool Engineers, American Welding Society, American Electroplaters' Society, and American Society of Naval Engineers.

Meetings

AND EXPOSITIONS

Jan. 6-8—

Fourth National Symposium on Reliability and Quality Control in Electronics to be held at Hotel Statler, Washington, D. C. Sponsors are American Institute of Electrical Engineers, Institute of Radio Engineers, American Society for Quality Control, and Radio-Electronics - Television Manufacturers Association. Additional information can be obtained from Mr. W. H. Rombach, Chief Quality Control Engineer, Philco Corp., 4700 Wissahickon Ave., Philadelphia 44, Pa.

Jan. 13-17—

Society of Automotive Engineers Inc. Annual Meeting and Engineering Display to be held at the Sheraton-Cadillac and Statler Hotels, Detroit. Further information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Jan. 27-30—

Plant Maintenance and Engineering Show and Conference to be held at the International Amphitheatre, Chicago. Additional information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 28-31—

Institute of the Aeronautical Sciences. 25th Annual Meeting to be held at the Sheraton-Astor Hotel, New York. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Feb. 2-7—

American Institute of Electrical Engineers. Winter General Meeting to be held at the Hotel Statler, New York. Additional information can be obtained from institute headquarters, 33 W. 39th St., New York 18, N. Y.

Feb. 4-6—

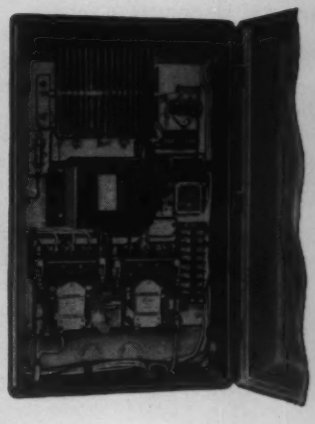
Society of the Plastics Industry Inc. 13th Annual Technical and Management Conference of the Reinforced Plastics Div. to be held at the Edgewater Beach Hotel, Chicago. More information is available from society headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 13-15—

National Society of Professional Engineers. Spring Meeting to be held at Michigan State University, East Lansing, Mich. Further information is available from NSPE headquarters, 2029 K St. N. W., Washington 6, D. C.

IMPROVE MACHINE TOOL PERFORMANCE

—with Westinghouse components ...ready today

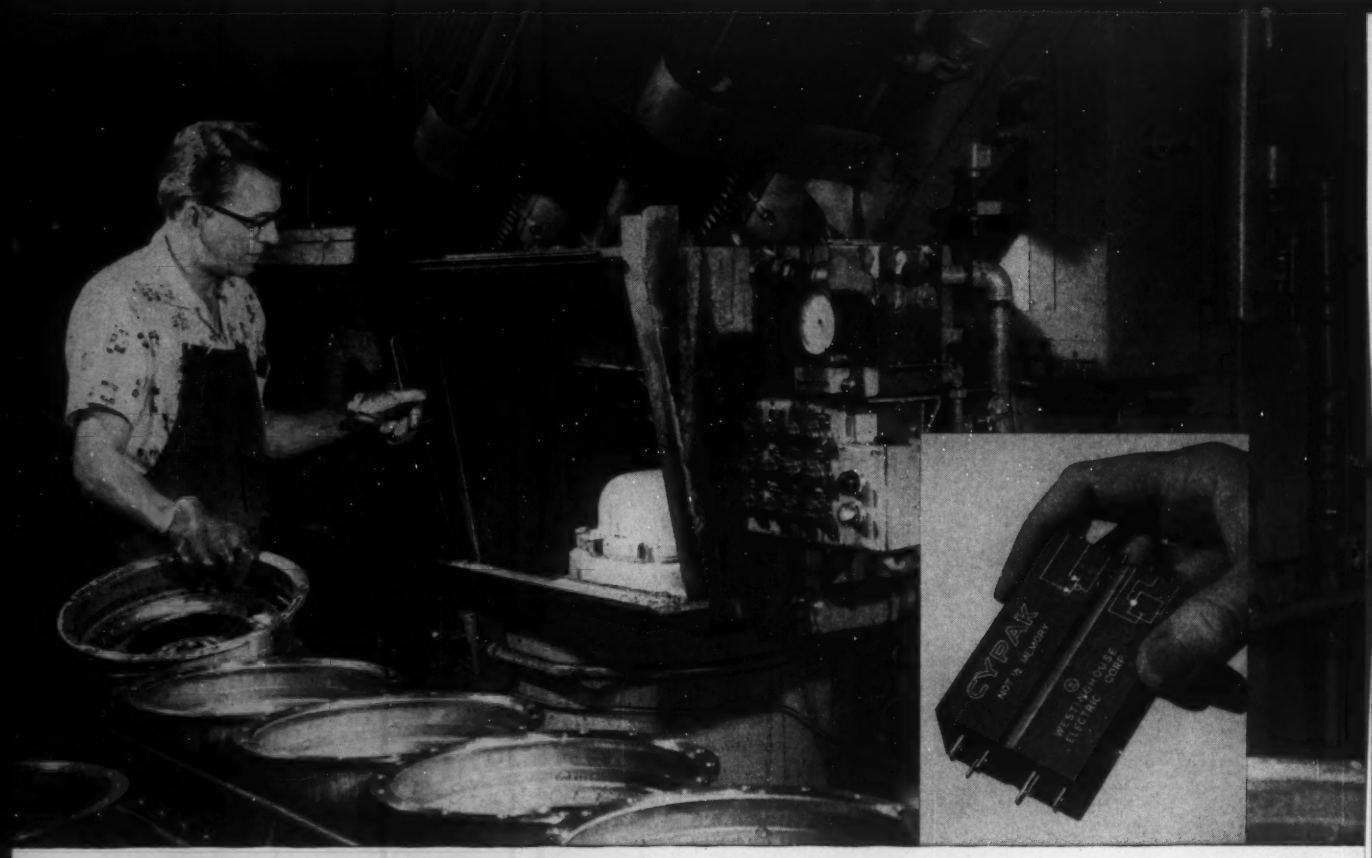


Stamping press performance improved at this plant when they used Westinghouse DYNAC braking control to reduce stopping time 95 percent.

MP-3057-1

YOU CAN BE SURE... IF IT'S Westinghouse

Circle 430 on Page 19



Westinghouse Cypak static control reduces maintenance costs in form-grinding automotive transmission parts.

THESE COMPONENTS OFFER IMMEDIATE ANSWERS

...for more dependable operation

...for quicker stopping...for faster duty cycles

You don't have to wait for electrical answers in making machine tool improvements or modifications. Outstanding design and improvement in Westinghouse control components, systems and drives help designers and their customers to act now.

For example, *Westinghouse DYNAC® braking control*, cover photo, reduces press stopping time 95 percent. The eight minutes it previously took to stop the heavy flywheel on this press have been cut to just 24 seconds with DYNAC. This operation is now getting the fastest, smoothest stops possible to increase production.

Cypak static control*, above, has already outlasted conventional relays previously used on form grinders at a large automobile manufacturer's plant. No down time for control maintenance has been necessary on this highly repetitive operation in over 17 months.

*Trade-Mark

Westinghouse Life-Line® "H" Motors, right, make possible faster, smoother reversing cycles to save production time. Westinghouse reduced armature inertia up to 55 percent and increased commutating ability 35 percent to provide in the Life-Line "H" Motor the fastest d-c motor response available to improve machine tool performance.

Westinghouse right-angle gearmotor, right, delivers up to 195 percent more torque capacity than conventional single-reduction worm gearmotors between 9:1 and 60:1 speed reduction ratios. It's the result of more efficient, double-reduction gear train. You'll find Westinghouse packaged motor-reducer drives offer rugged dependability, too, for improved machine performance.

Developments like these help you design and build machine tools that answer your customers' needs for increased productivity at lower cost. Whatever the function you want performed . . . sensing, transmitting, recording, computing, control or driving . . . think of Westinghouse components first!

MP-3057-2

YOU CAN BE SURE...IF IT'S Westinghouse

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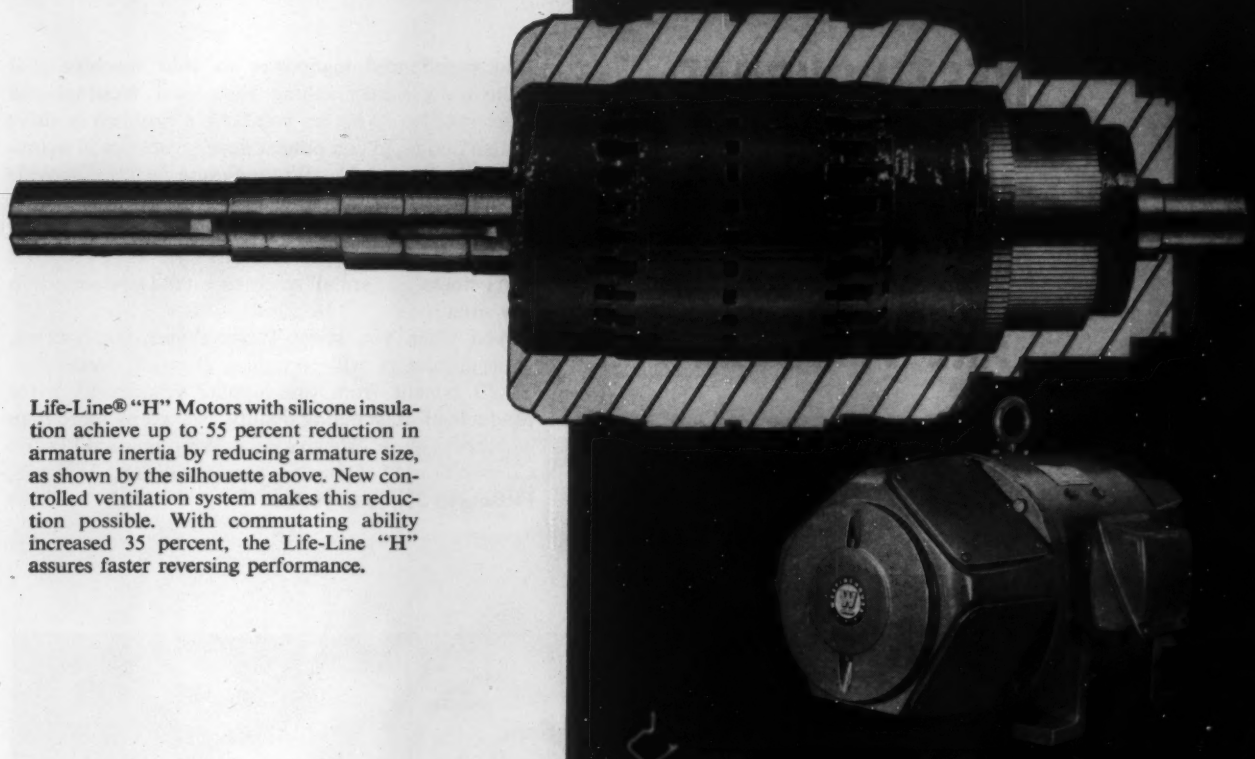


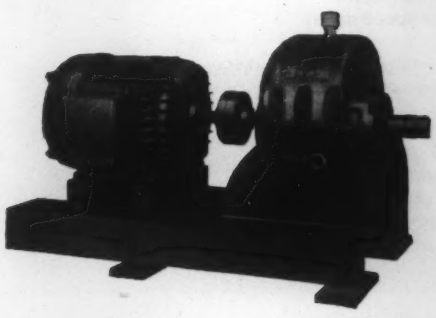
Life-Line® "H" Motors with silicone insulation achieve up to 55 percent reduction in armature inertia by reducing armature size, as shown by the silhouette above. New controlled ventilation system makes this reduction possible. With commutating ability increased 35 percent, the Life-Line "H" assures faster reversing performance.

Push-lite pushbuttons combine the functions of both a pushbutton and indication light in one unit. One push transmits the signal and energizes the indicating light. Push-lites are oiltight — part of the complete Oil-Tite* line of 1,500,000 pushbutton control arrangements available from stock.

*Trade-Mark

Either Westinghouse gearmotors or packaged motor-reducer drives save design time with a wide selection in horsepower, speed ratios, direction of power take-off, mounting and coupling methods.

MP-3057-3



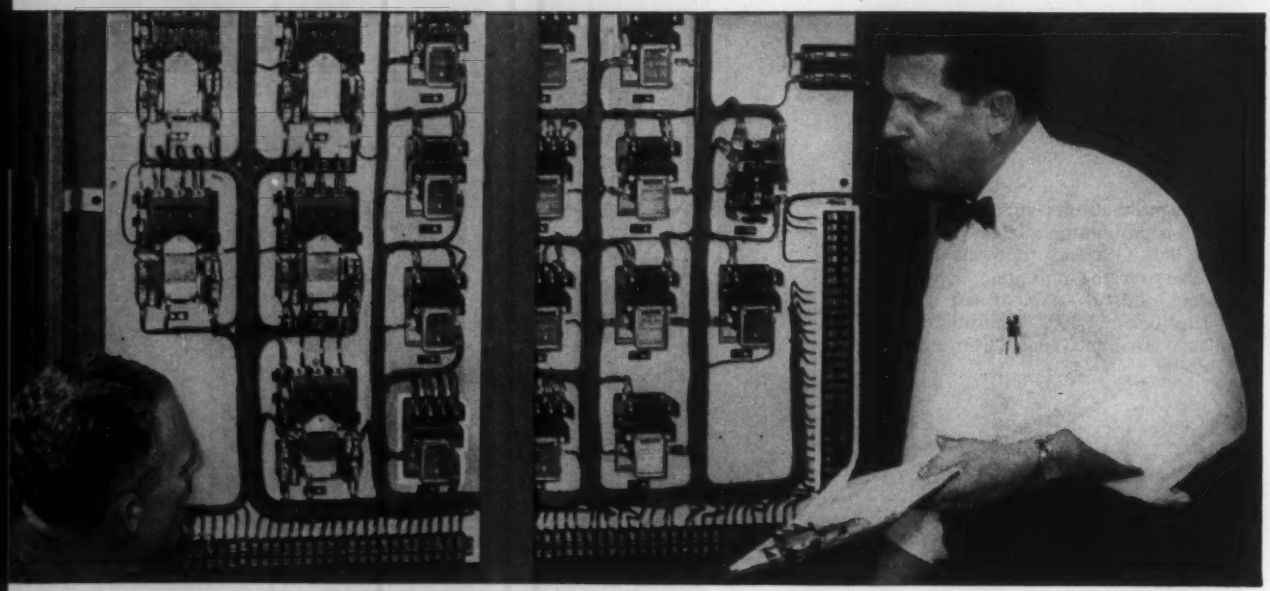
WESTINGHOUSE SERVICES AND FACILITIES ARE FLEXIBLE

HELP YOU FROM DESIGN BOARD TO TEST FLOOR

Add experienced manpower to your machine tool projects by simply calling your local Westinghouse representative. Whether you have a problem in drive system design, in component development or in manufacture and assembly, Westinghouse facilities provide economical ways to get the answer on schedule.

Westinghouse research . . . field engineering service . . . local manufacturing and repair plants . . . renewal parts stocks . . . are all ready to extend you service in any situation.

And when you select Westinghouse components, your customers will recognize electrical leadership. You'll benefit from one-supplier responsibility for products of outstanding quality, backed by more than 70 years of electrical experience. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. MP-3057-4



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Westinghouse serves these O. E. M. industries

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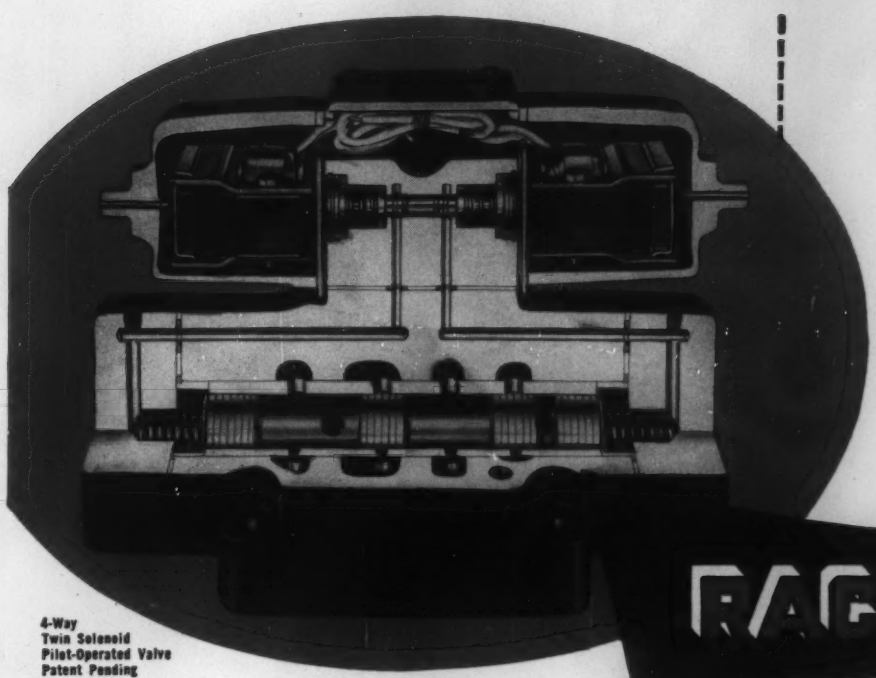
- Pump and compressor
- Miscellaneous machinery

. . . with these components

- Motors—gearmotors
- Adjustable-speed drives
- Gearing
- Controls—relays—circuit breakers
- Semiconductors
- Cypak*
- Magamp* magnetic amplifiers
- Rectifiers
- Heating elements—thermostats
- Transformers
- Instruments
- DYNAC® magnetic braking

*Trade-Mark

Circle 430 on Page 19



4-Way
Twin Solenoid
Pilot-Operated Valve
Patent Pending

RACINE®

SLEEVE TYPE VALVES GIVE BETTER CONTROL

Proper control of oil flow improves the operation of your machines.

RACINE Sleeve Type Valves are designed with round drilled parts that assure smooth, control of oil to cylinders and fluid motors.

These RACINE Valves are provided with dust-proof solenoid covers — a pending patent includes a RACINE feature that prevents solenoid operation and injury to operator when covers are removed or loose.

Built to J.I.C. specifications RACINE Valves are approved for use in all critical applications. They are precision-built, compact, and rugged in design. Operating pressures to 2000 psi with full back pressure on exhaust port.

Your machine will operate better, with less maintenance because of longer life of RACINE Sleeve construction. Write today for complete catalog showing why "Sleeve Type Valves give Better Control."

OTHER RACINE HYDRAULIC PRODUCTS

MODEL Q
Variable Volume
Vane Type
Hydraulic Pump

PRESSURE BOOSTER
Up to 5000 psi
Up to 7:1 pressure ratio

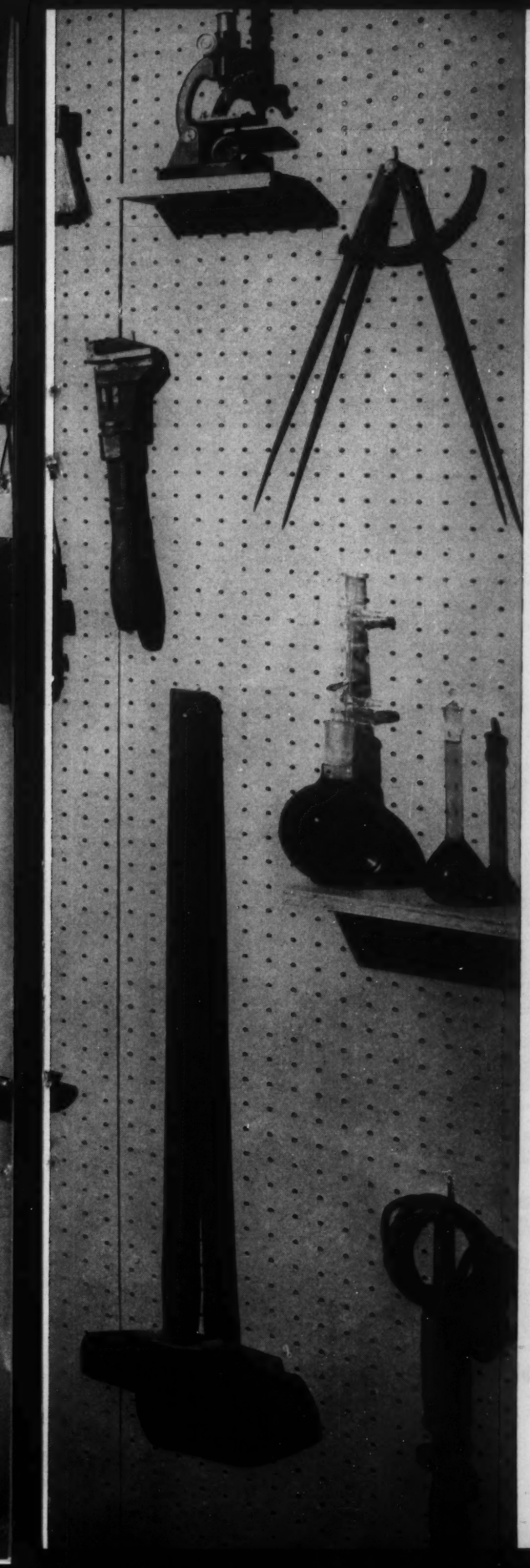
FLUID MOTOR
Vane Type
50 to 3500 rpm
Pressures to 1500 psi

RESERVOIR
With Control Panel
Designed to your space
and circuit requirements

RACINE

NFPA NATIONAL FLUID POWER ASSOCIATION

RACINE HYDRAULICS & MACHINERY, INC.
2073 Albert Street
RACINE, WISCONSIN, U. S. A.



Can a man be an expert in everything?

IT'S SAD BUT TRUE that the product design engineer of today has to be a many-faceted expert. He has to be an engineer *and* a materials expert *and* a production expert. He has to be well up on purchasing fundamentals, plus the elements of cost accounting.

There is one design responsibility from which we can give you some relief, though. That is the selection of springs. Spring design is a field unto itself, and, although we'll be glad to give you mountains of interesting information on the subject, why concern yourself with it? We'll do the work for you.

AS&W spring engineers will gladly work with you to select the right combination of spring characteristics that will do the job well. Most important: they may be able to suggest a slight design change that will drastically lower the *cost* of the spring.

Just call your nearest AS&W representative.

AMERICAN STEEL & WIRE DIVISION
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GENERAL OFFICES: CLEVELAND, OHIO
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USS AMERICAN *QUALITY* SPRINGS

UNITED STATES STEEL

Circle 432 on Page 19

Vickers Magneclutch for Better Torque Transmission . . .

VICKERS®

Magneclutch®

solves difficult tension control problem in slitting machine operation

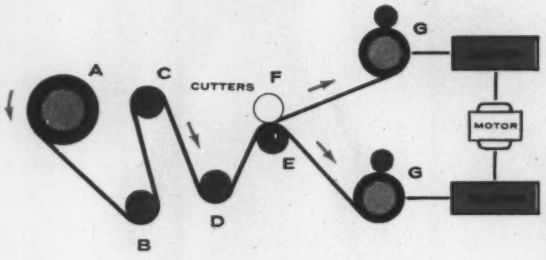
This specialized machine by Gudeman Company of Chelsea, Michigan, slits mil-thick materials such as paper and metal foil for use in capacitors.

As the feed roll is unrolled, slit and rewound, the tension on the material as it passes through the slitting knives and rollers must be accurately controlled, to assure uniform rewinding and to prevent strains, breakage or snarling.

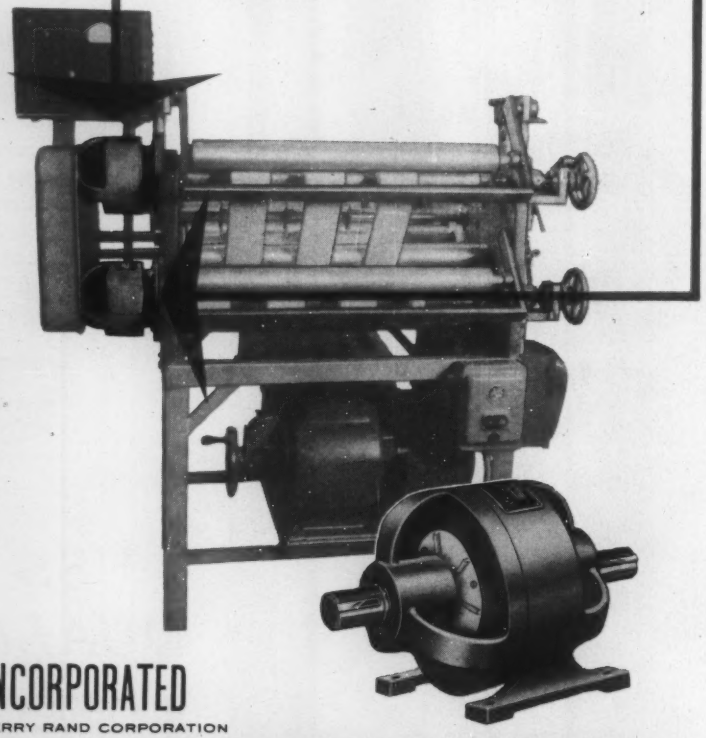
The manufacturer was able to obtain this necessary tension control independent of speed only with the Vickers Magneclutch, after mechanical clutches had failed because of changing characteristics and difficulty in adjusting to changing tension demands.

This, of course, is only one of many practical uses for the Magneclutch, the magnetic particle clutch that provides smooth operation without grab or chatter, torque at zero slip, fast response, and long life because there's no wear on torque transmitting surfaces.

Write for complete information and literature.



Rollers B, C and D pull the material from the unwind roll and establish the speed at which the material flows through the machine. The torque transmitted by the Magneclutch establishes the tension in the material between roller D and roller G. As the diameter of the windup roll increases, the clutch slips automatically, permitting the material to wind up at a constant speed and tension.



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VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

ELECTRIC PRODUCTS DIVISION

1881 LOCUST STREET • SAINT LOUIS 3, MISSOURI

Circle 433 on Page 19

WORTHINGTON QD SHEAVES — THE ORIGINAL 2-PIECE DESIGN

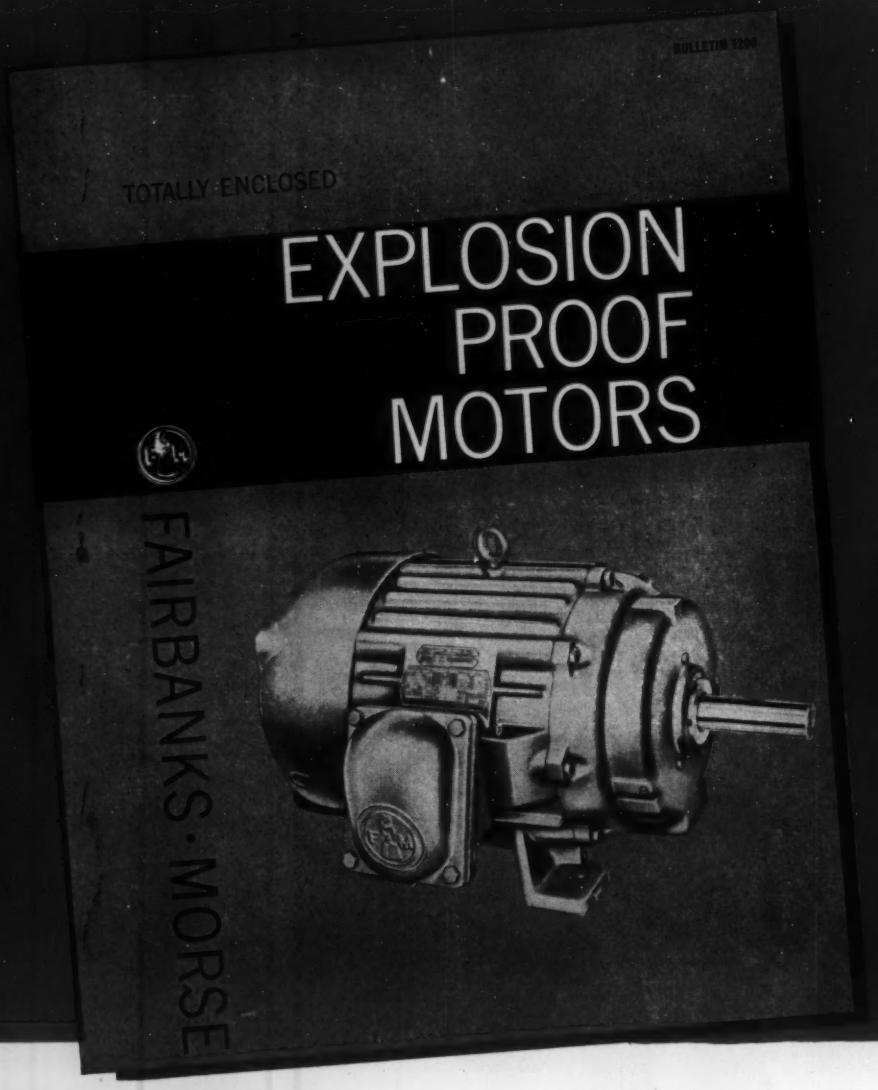
EASY ON!

Only Worthington QD sheaves have the exclusive two-piece design that lets you install the sheave *one part at a time.* No heavy rim and hub combination to delicately inch into place. The QD's tapered hub slides easily on the shaft, locks with a cap screw for permanent alignment. A set screw locks the key in place. Sheave pulls up tight with heat-treated bolts.

WORTHINGTON

Circle 434 on Page 19

NEWEST MOTOR TO CARRY UNDERWRITERS' LABEL



FAIRBANKS-MORSE

EXPLOSION PROOF

All new inside and out—new, rugged frame design . . . for new, improved performance in all Class I, Group D, and Class II, Group E, F and G hazardous locations.

Get full information . . . send for Bulletin 1200 on new Fairbanks-Morse line of totally enclosed, explosion-proof motors. Write today: Fairbanks, Morse & Co., Dept. MD-12-12, Chicago 5, Ill.

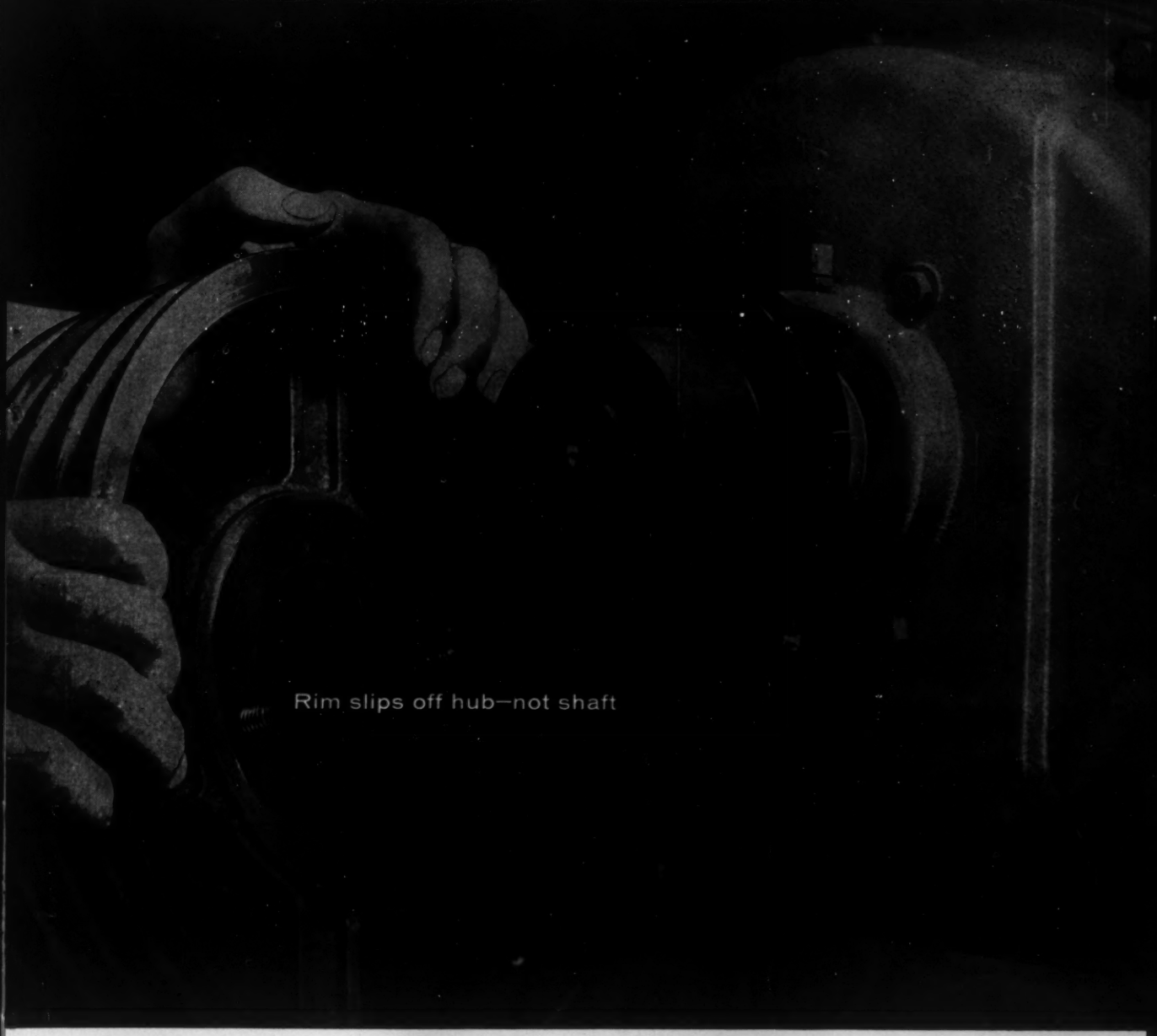
FAIRBANKS-MORSE

a name worth remembering when you want the BEST

ELECTRIC MOTORS AND GENERATORS • DIESEL LOCOMOTIVES AND ENGINES • PUMPS • SCALES • RAIL CARS • HOME WATER SERVICE EQUIPMENT • MAGNETOS

Circle 435 on Page 19

WORTHINGTON QD SHEAVES—THE ORIGINAL 2-PIECE DESIGN



EASY OFF!

Loosen the big bolts, use two for jack screws and the sheave practically comes off by itself! To change speed it's a simple matter to mount a larger or smaller sheave on the hub which remains aligned on the shaft. This easy on, easy off feature is the big advantage of Worthington QD sheaves—the only design that lets you install or remove one part at a time.

WORTHINGTON

Circle 434 on Page 19

How CRUCIBLE FATIGUE RESISTANT SPRINGS are made stronger to last longer...

First, every Crucible *fatigue resistant* industrial spring is shot-peened. It's the best way to insure high fatigue resistance under rugged operating conditions. And it makes the spring stronger by eliminating stress concentration points that could lead to spring failure.

But, most important, Crucible gives you full measure of the two factors upon which good springs depend: good spring design, and fine steel.

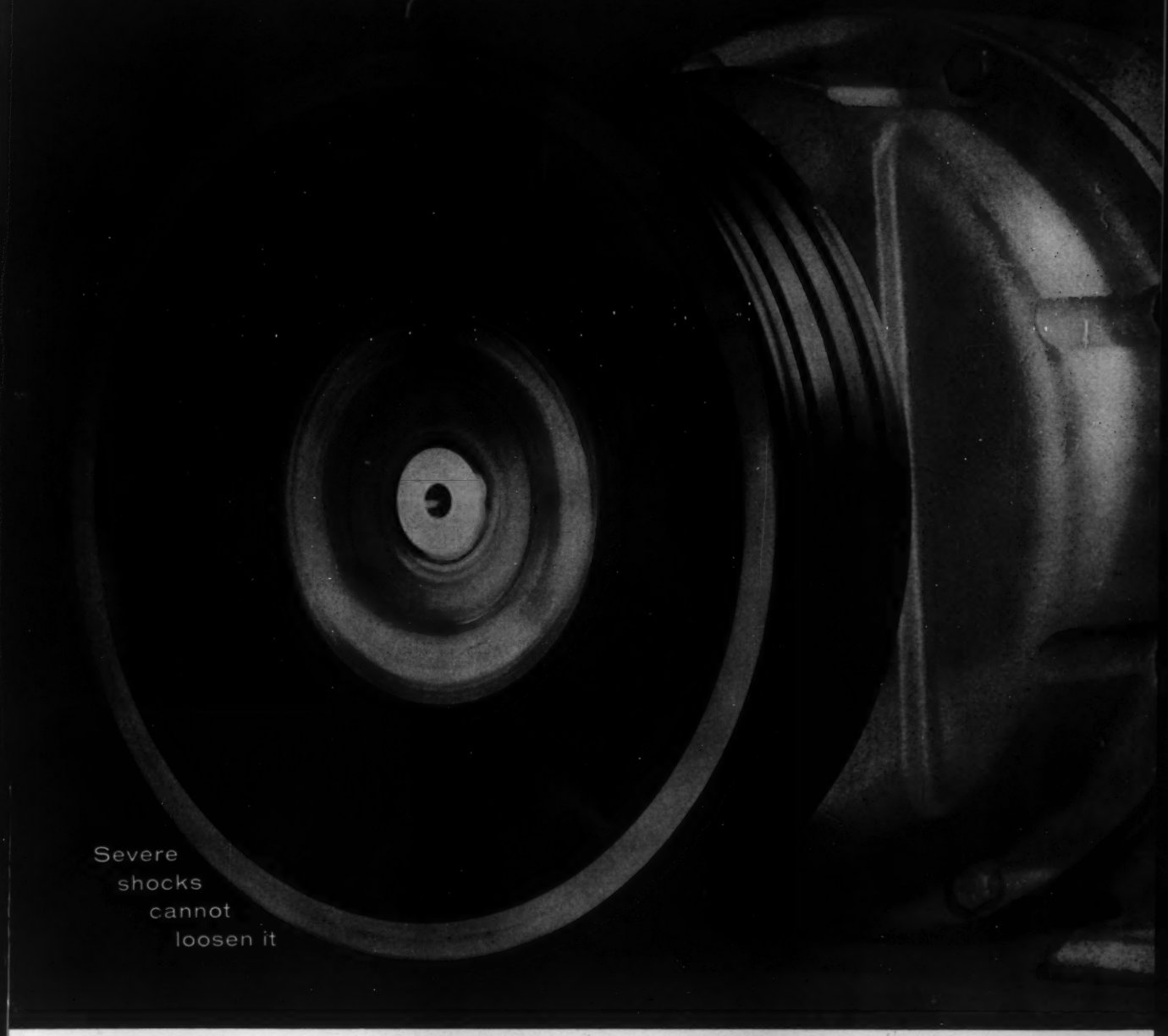
In addition to Crucible's staff of proven spring designers and spring makers is Crucible's years of experience in fine steel making—from ore to finished spring. When you have a spring application, let an experienced Crucible spring specialist suggest the best spring for it. And write for a free copy of the "Handbook of Coil Spring Design". *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

CRUCIBLE spring division

Crucible Steel Company of America

Circle 436 on Page 19

WORTHINGTON QD SHEAVES—THE ORIGINAL 2-PIECE DESIGN

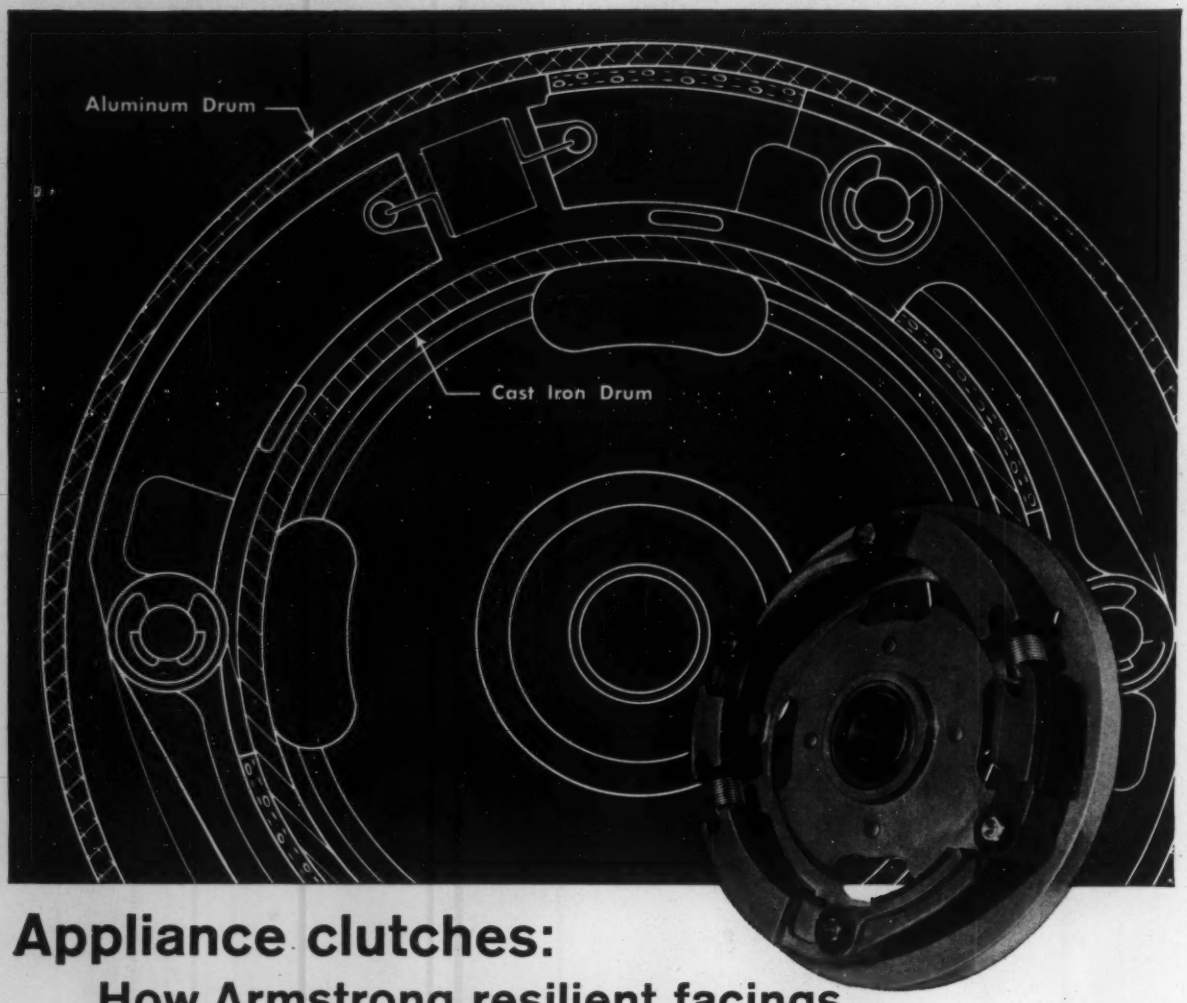


ALWAYS TIGHT!

Severe shock overloads or reversing applications cannot loosen a Worthington QD sheave. The secret is the two-piece construction with the vice-like grip. Tightening the pull-up bolts forces the tapered hub to securely lock the shaft as tight as if the sheaves were integrally cast with the shaft (comparable to a press fit.) To keep the key from drifting, the set screw—another Worthington exclusive—anchors it in position.

WORTHINGTON

Circle 434 on Page 19



Appliance clutches:

How Armstrong resilient facings cut costs and extend service life

Five resilient facings with a total area of less than three square inches helped General Electric reduce unit cost and increase service life of the clutch in its two-speed Filter-Flo* washers.

Four of these facings are attached to the carrier plate shown above and engage centrifugally. For this application, General Electric engineers wanted a material with a high coefficient of friction to provide positive engagement under minimum closing pressure. In addition, it had to be a material that could be depended upon for years of trouble-free performance.

Armstrong NC-733 met these requirements and reduced costs as well. The fifth facing, when activated by a solenoid, engages the rim of the carrier plate, putting the clutch in "low." Here, NC-733 created the necessary holding torque under so little pressure that a small, inexpensive solenoid and linkage system could be used.

In thousands of General Electric Filter-Flo washers, Armstrong NC-733 friction material is now helping to provide efficient clutch operation.

This is one of many Armstrong resilient facings being used in hundreds of applications—from sensitive laboratory instruments to earth-moving equipment. Perhaps one of these materials can cut costs and improve performance in your product.

Send for free booklet

A new booklet describing our full line of resilient facings will soon be available. Write today and reserve your copy of "Armstrong Resilient Friction Materials." Address Armstrong Cork Company, Industrial Division, 7212 Dean Street, Lancaster, Pennsylvania.

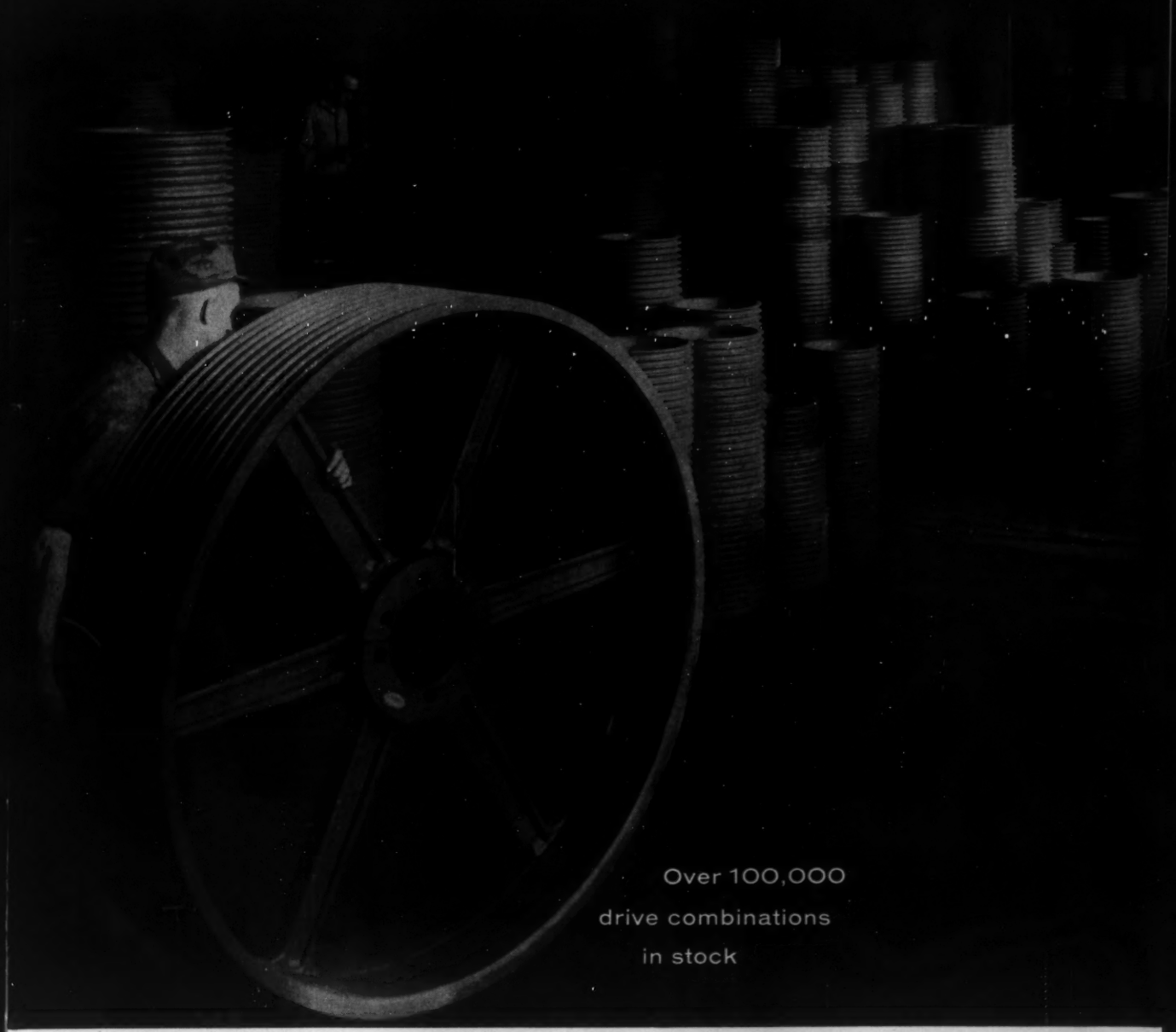
*Trade-mark Registered by General Electric Company

Armstrong RESILIENT FRICTION MATERIALS

. . . used wherever performance counts

Circle 437 on Page 19

WORTHINGTON QD SHEAVES — THE ORIGINAL 2-PIECE DESIGN



COMPLETE STOCK!

You can get Worthington QD sheave stock service anywhere in the U. S. A. More than 350 distributors stock Worthington sheaves and Worthington-Goodyear V-belts. In 13 giant factory warehouses alone there are over 250,000 units in stock from fractional hp sheaves to 1,000 hp giants. For your free copy of a 100-page Multi-V-Drive Manual that enables you to select the right sheave and V-belt in 3 minutes flat write to Section MV-74, Worthington Corp., Harrison, N. J.

WORTHINGTON

Circle 434 on Page 19

Announcing—the new, improved

New sturdier construction! New heavier jacket! Improved Sealtite* E.F. offers new superior performance in equipment . . . new installation ease. No extra cost!

Sealtite Type E.F.†—the original flexible, liquid-tight conduit, first to meet J. I. C. standards—is now better than ever. New design has made it stronger, tougher, more durable in service . . . easier to install.

Over-all construction is improved. Heavier extruded PVC jacket offers greater resistance to abrasion, cutting and tearing . . . greater oil resistance . . . greater holding power for fittings.

It is more flexible—permits smaller bending diameters. New convenient markings save time, prevent waste. Length is indicated by arrows at 1-foot intervals. Trade size in inches is also shown on cover.

Available in handy cartons, or nonreturnable reels,

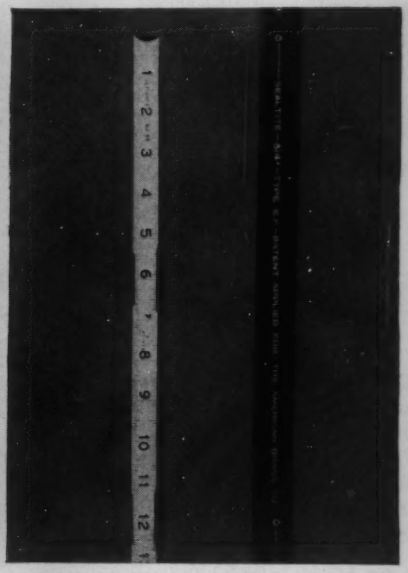
STRONGER. Over-all construction is stronger, more durable.

TOUGHER. Thicker PVC jacket resists abrasion, cutting, and tearing.

MORE OIL RESISTANCE. Liquid-tight jacket keeps out all foreign matter.

GREATER HOLDING POWER FOR FITTINGS — easier attachment.

GREATER FLEXIBILITY — smaller bending diameters — smoother cover even when flexed.



NEW MARKINGS — length and trade size are indicated at 1-foot intervals.

Sealtite E. F. flexible, liquid-tight conduit

at no extra cost. Reels simplify handling and cutting, reduce scrap, simplify storage, have handy charts for a running inventory.

Sealtite types E.F. and U.A. (U.A. is approved by Underwriters' Laboratories) in both black and machine tool light gray. For information, write: The American Brass Company, American Metal Hose Division, Waterbury 20, Conn. *Trademark †Pat. Applied For 57199

Insist on the conduit marked

SEALTITE

an ANACONDA® product

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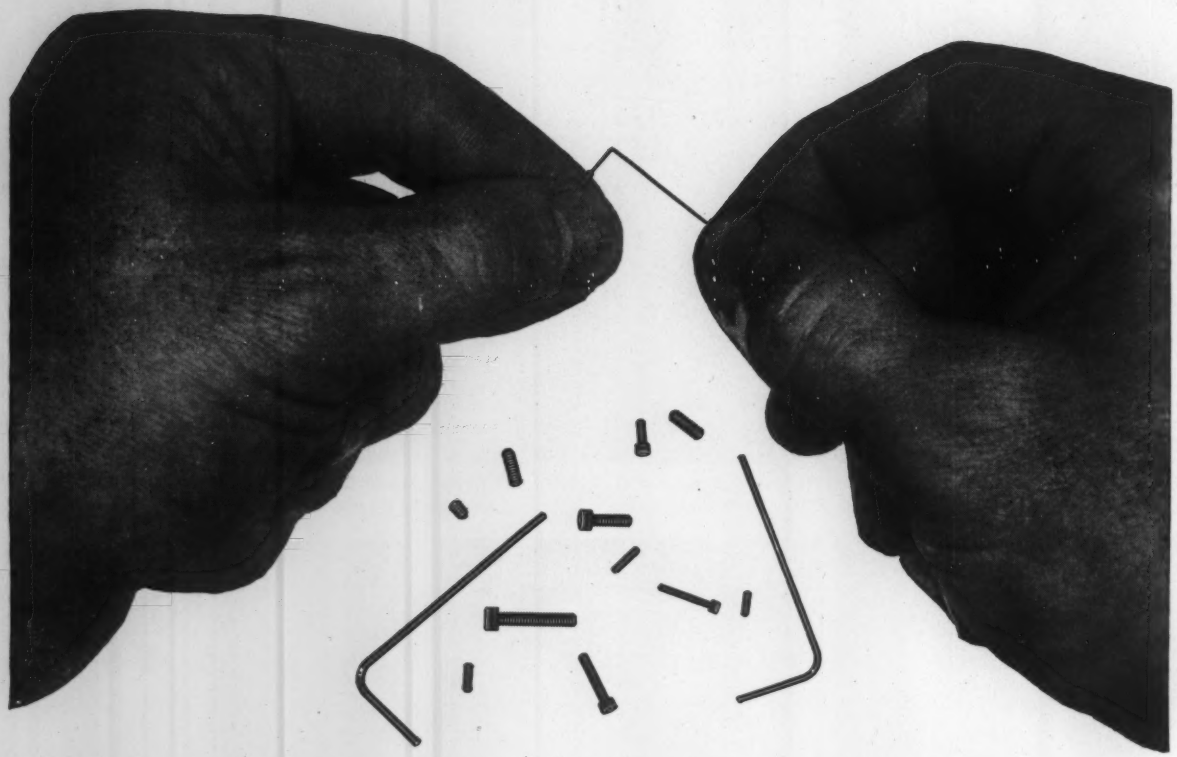


If you're miniaturizing . . . you'll save space, time and money with Allen Minicaps and Minisets (#0 thru #3 dia.)

These miniature Allen Hex Socket Cap and Set Screws will let you scale down your product sizes even farther. They're made from Allenoy special alloy steel — so strong that you can safely specify fewer screws or smaller sizes.

Allen Minicaps and Minisets are tiny, but very tough! — true Allens, with deep, clean, strong sockets and uniform Class 3A threads. Minicaps have the Allen knurled "Grip-Head" and are trimmed both on top and *under* the head, for tighter fit and better appearance. Minisets have the improved small-cup Allenpoint that drives deeper and holds tighter.

Because sockets are uniformly true hexagon shape, the key or driver fits tight — makes starting much easier, saves a lot of time in assembly.

Diameters of these miniatures run from #0 through #3. Minicap lengths run from ⅛" through ½", and Miniset lengths from 1/16" through ¼". Also standard in stainless steel. Your Industrial Distributor has them now. He'll show you why these Allens — like all Allens — hold tighter and last longer. Or write for information and samples.

Use Minicaps and Minisets wherever you need dependable fastening in very small assemblies:

TV, radio and telephone equipment • Guided missiles, rockets • Panel meters • Electro-mechanical devices and servo-systems • Computers • Control and operating mechanisms for relays • Cameras • Instruments

Stocked and sold by leading industrial distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 2, Connecticut, U.S.A.

ALLEN HEX-SOCKET SCREWS HEAD

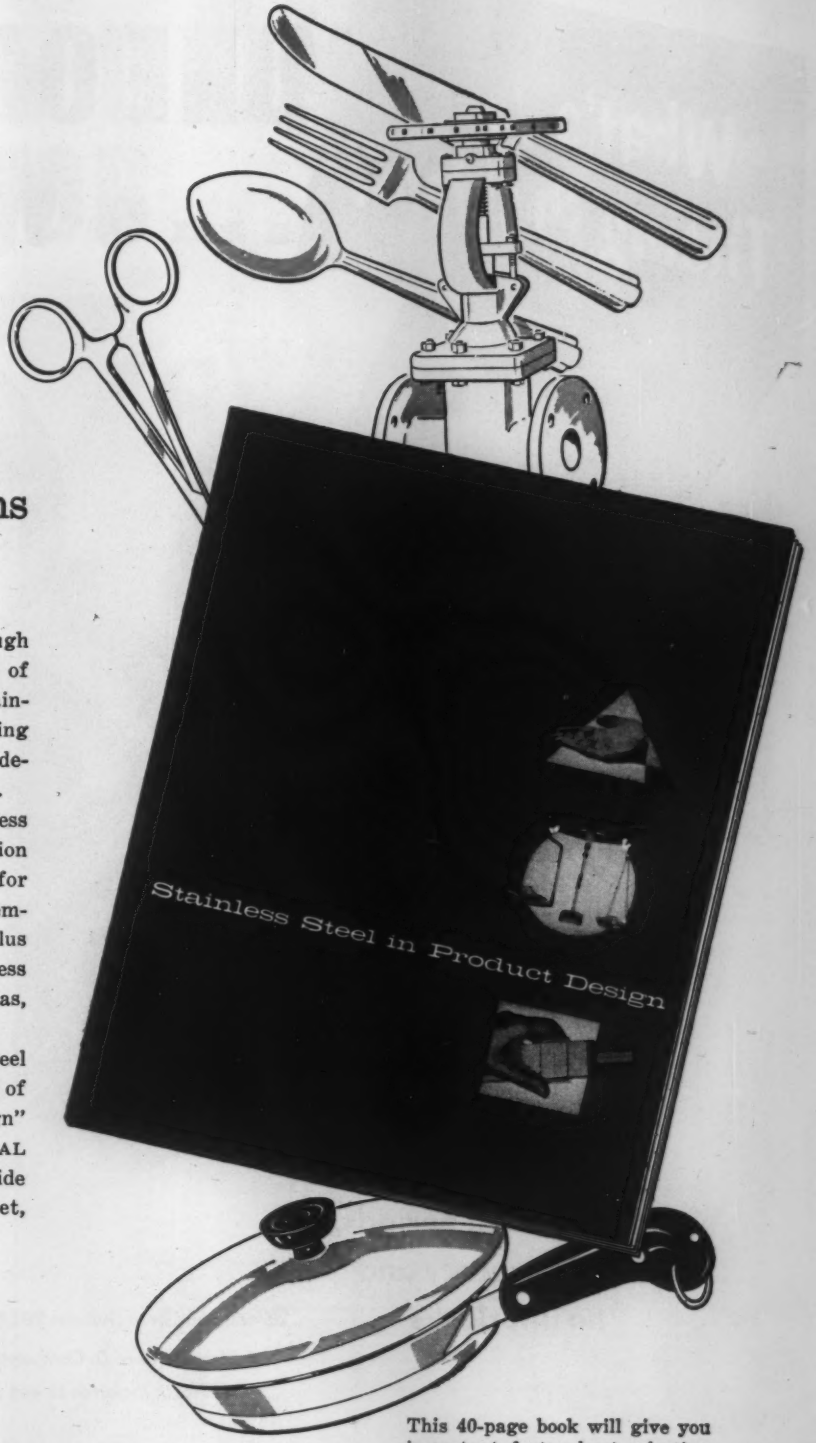
STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on the sale of new designs

Designers gain prominence through the effectiveness and saleability of their work. The sales appeal of stainless steel is a powerful tool for selling new designs. It has turned many design ideas into profitable products.

The recognized merits of stainless steel, such as strength and corrosion resistance, make it equally "right" for housewares, jet engine parts, or chemical equipment. These qualities plus a variety of finishes have put stainless into planes, trains, cars, cafeterias, and scores of other places.

For more facts about stainless steel see your supplier. For a free copy of "Stainless Steel in Product Design" write: ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.



This 40-page book will give you important facts about selecting and applying stainless steel. Write for it today.

METALS DO MORE ALL THE TIME ...THANKS TO ALLOYS

Electromet
FERRO-ALLOYS AND METALS

UNION CARBIDE

The terms "Electromet" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 440 on Page 19

What's Your Timing Problem?

ONE OF THESE WILL DO

NEW TYPE A

Really Small in Size and Cost!

for applications requiring shorter timing periods, ±15% accuracy and no interlocks

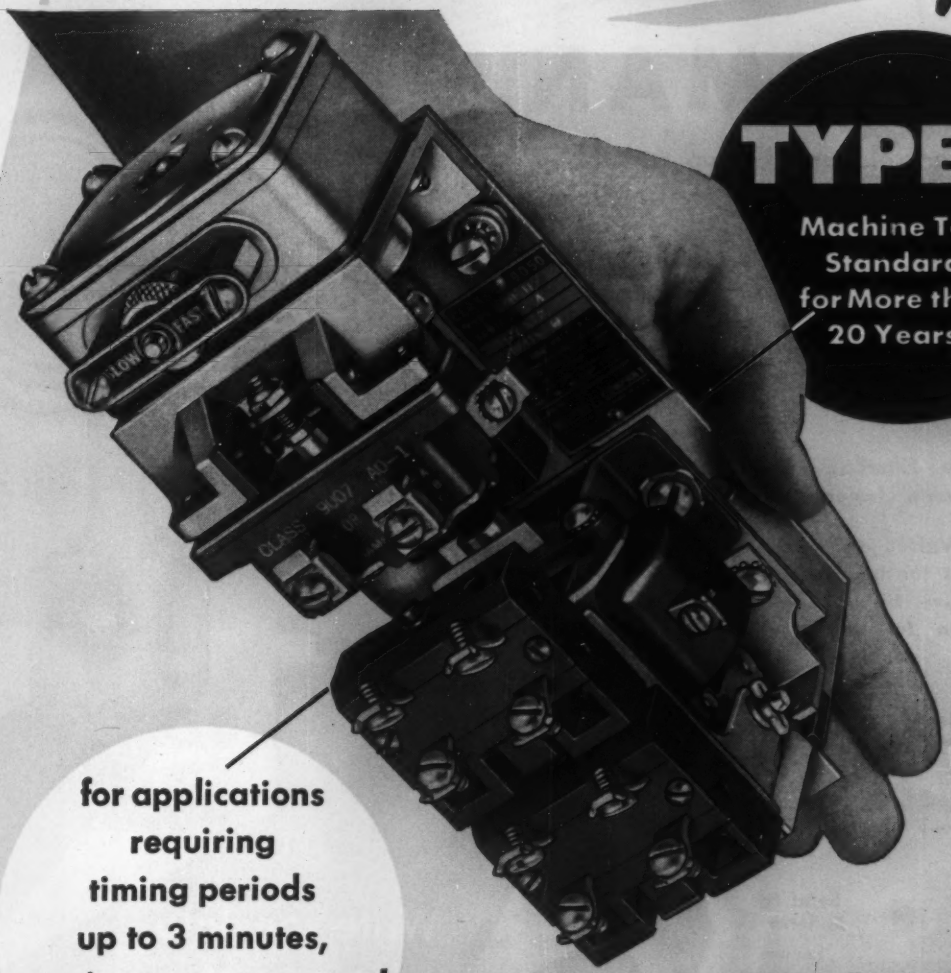
Write for Timer Bulletin 9050

Address Square D Company,
4041 North Richards Street, Milwaukee 12, Wisconsin

NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE

SQUARE D COMPANY

SQUARE D TIMERS YOUR JOB....*Exactly!*



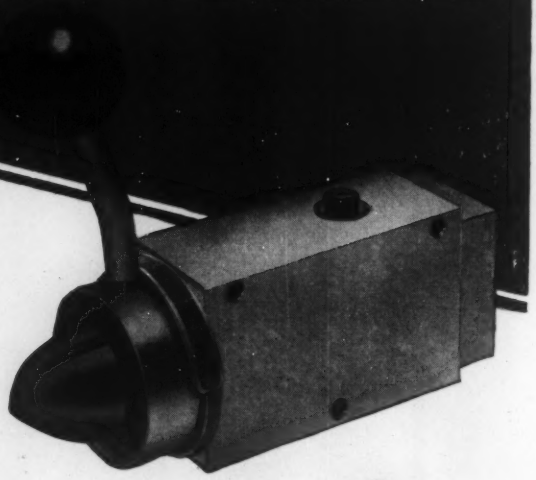
for applications requiring timing periods up to 3 minutes, maximum accuracy and 1 or 2 instantaneous interlocks

COMPARISON	TYPE A	TYPE B
Timing Period	.2 to 1 min.	.2 to 3 min.
Accuracy	±15%	±10%
Interlocks	None	Max. 2 Double Circuit
Panel Space	2⅜" x 4"	2½" x 7⅛"
Convertible Delay-On • Delay-Off	Yes	Yes
Maximum Voltage, AC-DC	600 V. AC only	600 V. AC • 250 V. DC

Everybody's Ahead with Square D!

Circle 441 on Page 19

For SAFE, DEPENDABLE ENGINEERED for DURABILITY . . . CONTROLS



CONSULT WATERMAN

Waterman controls are known for their accuracy, dependability, safety, and low maintenance cost.

Adjustable Flow Regulators range from 0.5 GPM to 20 GPM. They maintain a constant rate of flow regardless of resistance or pressure fluctuations.

No. 1 Check Valves are one piece, Nylon Poppet, aluminum body and low pressure drop.

No. 2 Micronic Line Filters have operating pressures to 3000 psi, 40 micron filtration, replaceable elements, and are available in ⅜" and ¾" NPT.

No. 3 Solenoid Valves are inexpensive, compactly built units for hydraulic systems handling non-corrosive fluids. Capable of continuous operation for working pressure to 3000 psi.

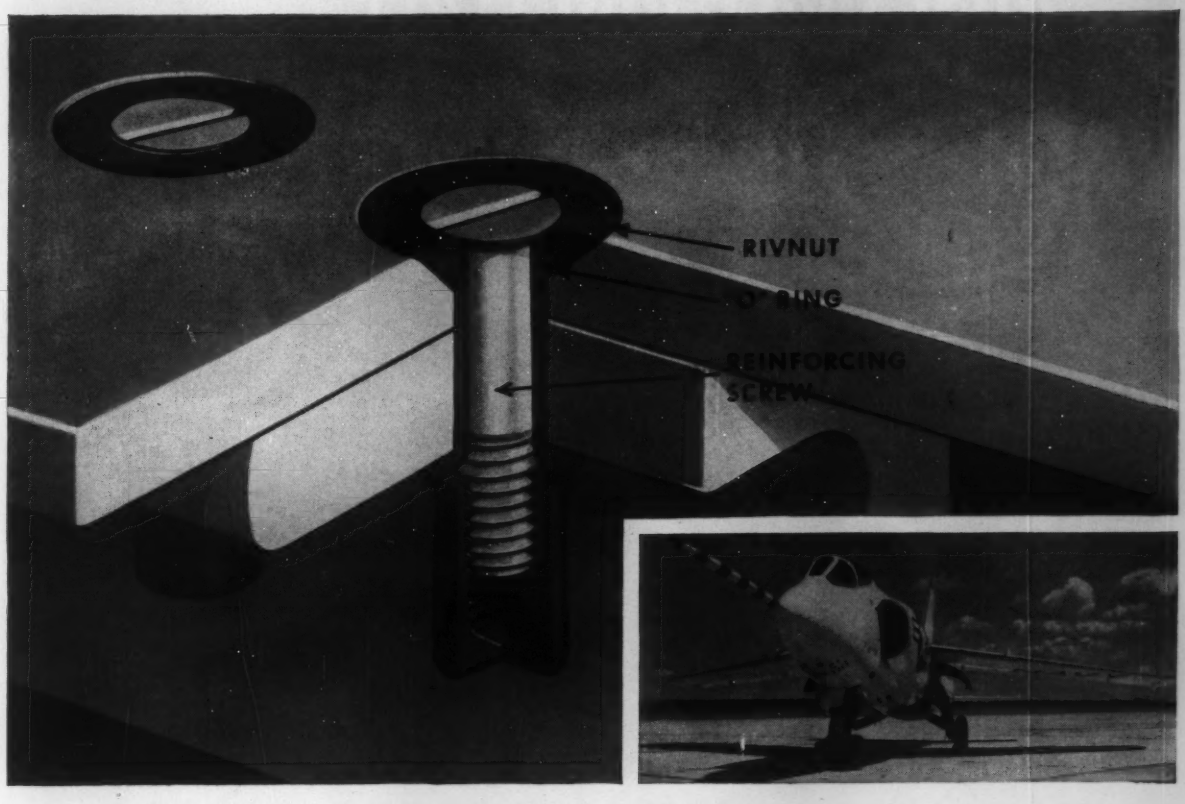
No. 4 Unloading Valves for pressures to 3000 psi. Flow rates to 30 GPM. Fast acting, maintain desired pressure without continuous readjustments.

Send for Bulletin E

WATERMAN ENGINEERING COMPANY

725 CUSTER AVENUE — EVANSTON, ILLINOIS

B.F.Goodrich Rivnuts®



New Seal-Head Rivnut simplifies integral wing tank assembly

GRUMMAN ENGINEERS wanted to use integral wing tanks to stretch the range of their F11F-1 Tiger. Fuel tank walls would be the single top and bottom aluminum skin panels that form each wing. The problem was to find a blind fastener that could join the wing sections tightly enough to withstand the strains of supersonic flight and still prevent loss of fuel.

Working with Grumman, B.F.Goodrich engineers solved the problem by developing a Seal-Head Rivnut with rubber "O" ring, approved for primary structure. The cross section above shows how it works.

The new B. F. Goodrich Seal-Head Rivnut is a precision-ground steel fastener with high tensile strength. Installed in a drilled and countersunk hole, the Rivnut actually rivets the sections together. The "O" ring makes a fuel-tight seal and withstands temperatures from —65° to 225°. Then a special screw, available in tensile strengths up to 165,000 p.s.i., is screwed into the Rivnut to further reinforce and secure it against strain and vibration.

Whatever your fastening problem, write Department MD-127,

SEND NOW FOR FREE DEMONSTRATOR

Shows with motion how you can use Rivnuts in aircraft fastening jobs. Explains construction, simplicity of installation. Send for yours today.

B.F.Goodrich

B.F.Goodrich Aviation Products

a division of The B. F. Goodrich Company, Akron, Ohio

Circle 443 on Page 19

Lightweight, portable tracing unit is only 1 7/16 inches *thin*

Now you can trace *right at the drawing board*, and save precious minutes with PORTA-TRACE®—the thin, lightweight tracing box that *comes to you.*

Simply pick it up . . . place it on your board . . . flick a switch and you're ready —in seconds!

Only 1 1/16 inches deep, PORTA-TRACE can actually be used under the straight edge of your drafting table! Its flush top permits use with drawings larger than unit itself. Strong Plexiglas top is enclosed by rugged, long-life stainless steel frame. Available in four sizes up to 24″ x 36″.

Save drafting time and precious space with PORTA-TRACE. Call your local Ozalid representative or write Ozalid, Dept. GG12, Johnson City, N. Y.

A Division of General Aniline & Film Corporation
In Canada: Hughes Owens Company, Ltd., Montreal

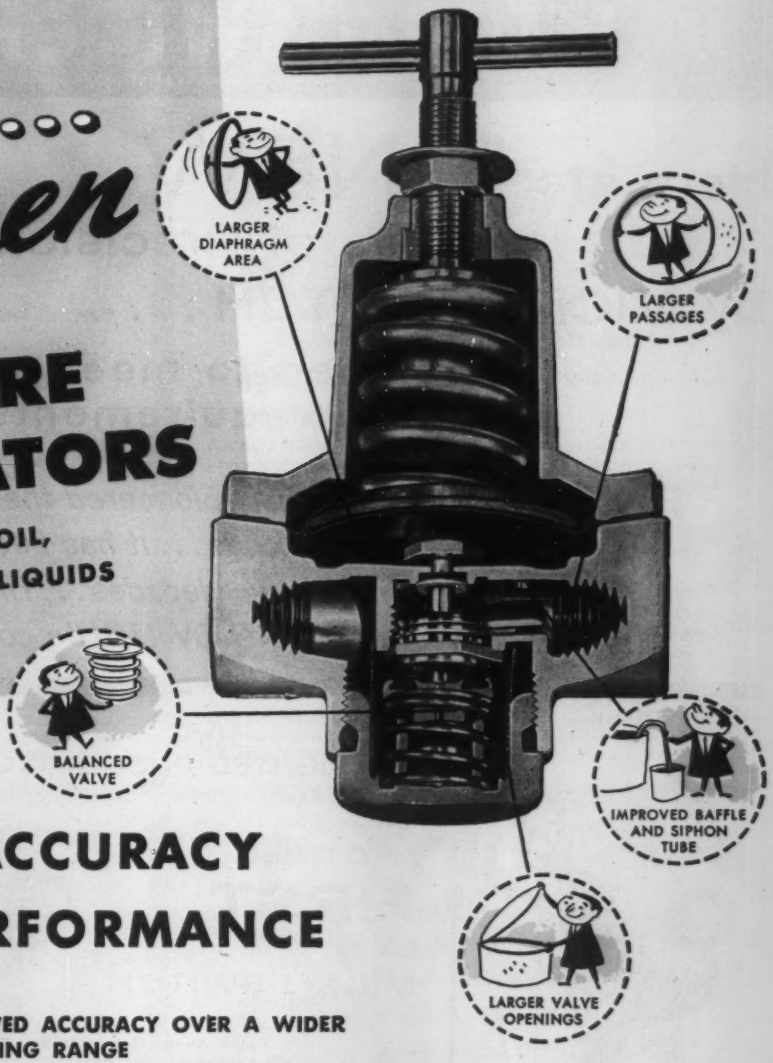
Circle 444 on Page 19

NEW...

Norgren

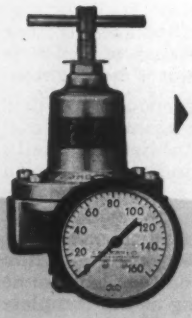
PRESSURE REGULATORS

FOR AIR, WATER, OIL,
NON-CORROSIVE LIQUIDS
AND GASES



GREATER ACCURACY
BETTER PERFORMANCE

- **IMPROVED ACCURACY OVER A WIDER OPERATING RANGE**
- **GREATER ACCURACY OF REGULATED PRESSURE** even with widely fluctuating line pressure and rapidly varying flow.
- **LARGER FLOW CAPACITY**
  - a. Balanced Valve Construction
  - b. Greater Effective Diaphragm Area
  - c. Improved Baffle and Siphon Performance
  - d. Larger Passages
  - e. Larger Valve Openings
- **RELIEVING AND NON-RELIEVING TYPES AVAILABLE FOR AIR**



For complete information on all your regulator needs, ⅛" to 2" inclusive, call your nearby Norgren Representative listed in your telephone directory — or WRITE FACTORY FOR LITERATURE.

C. A. NORGREN CO.

3442 SO. ELATI STREET • • • ENGLEWOOD, COLORADO

Circle 445 on Page 19

MICRO SWITCH Precision

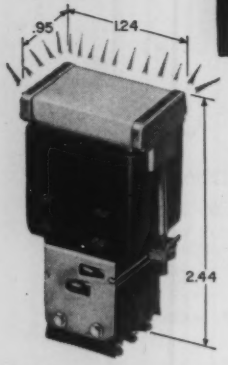
...FIRST IN PRECISION SWITCHING

Here are 5 NEW Series of Precision Switches by MICRO SWITCH...

Designed to meet modern electrical control requirements

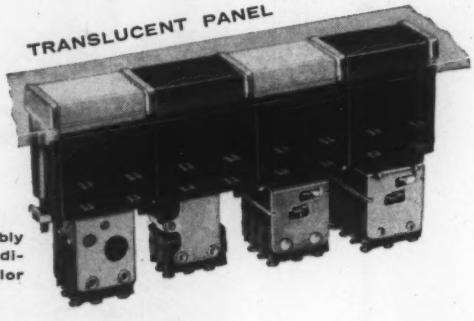
MICRO SWITCH pioneered the development of precision switches... It has been first in precision switching for two decades... These new switches are typical of MICRO SWITCH's continuing leadership.

NEW! LIGHTED PUSHBUTTON SWITCHES



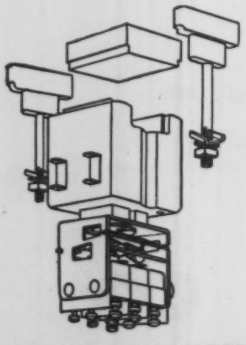
Typical switch module (a 3-circuit design)

ANOTHER **FIRST** BY MICRO SWITCH



A typical compact assembly of switches in panel slot. Indicates choice of button color and number of circuits.

- LARGE, EASILY ENGRAVED BUTTONS... EASILY INSTALLED IN COMPACT ASSEMBLY
- THREE TYPES OF ILLUMINATED SIGNAL
- WIDE CHOICE OF CIRCUITRY



Exploded view Series 100 PB switch showing button and mounting means.

MICRO SWITCH Series 100PB Lighted Pushbutton Switches provide a neat, good looking panel. Their compact mounting allows more switches per panel.

Because separate terminals are provided for each lamp and for each element of the contact structure, these switches permit intermixing of voltages, a-c or d-c current and even combinations of opposing polarities.

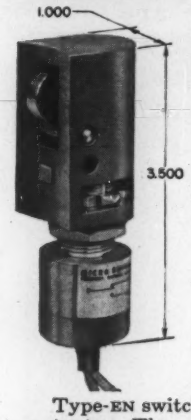
Three types of illuminated signals are provided: (1) one-color buttons, (2) two colors (lighted singly or in combination) and (3) choice of either of two colors—neither of which is visible when button is not lighted.

Buttons are large enough to allow two lines of clearly legible engraving. The switch assemblies are easily mounted, either individually or in strips, by cutting a single slot in the panel.

Matching indicating lamp assemblies are available with the same button and lamp combinations and same means of mounting as the complete 100PB switch assembly.

(Send for Data Sheet 143)

Switches have uses unlimited



NEW!

MICRO SWITCH "Rocket Switch"— a rugged, sealed small switch for indicating and lockout devices

Developed for use on rocket launchers, this MICRO SWITCH 21AS2 assembly fits the needs of many industrial designs.

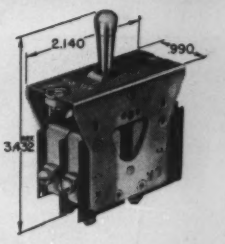
The assembly consists of one SPDT Type-EN switch attached to a rugged cam-type actuator. The assembly is environment-proof and withstands the highly-corrosive effects of rocket propulsion gases. The assembly will withstand heavy impact hammer blows on the actuator.

(Send for Data Sheet 120)

SWITCH CHARACTERISTICS

Operating force—6 to 12 lbs. Full overtravel force—10 lbs. min.; Release force—4 lbs. min.

Electrical Data: 28 vdc rating: inductive, 3 amps. at sea level and 2 amps. at 50,000 feet; resistive, 4 amps. at sea level and 50,000 feet; inrush, 24 amps. at sea level and 50,000 feet. Motor, 4 amps. at sea level and 50,000 feet; inrush, 24 amps. at sea level and 50,000 feet. (Altitude ratings established with seal deliberately broken.)



NEW!

MICRO SWITCH three-position toggle switch—4 SPDT circuits with a single lever

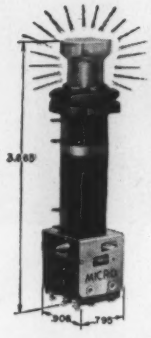
MICRO SWITCH 115AT Series of toggle switches uses four SPDT switching units. Two units are actuated in each extreme toggle lever position. None are actuated when lever is in center position.

Many different combinations, however, may be obtained, including the make and break of circuits in all three lever positions.

Outstanding features of this series include the compact design, positively-driven switch actuators and sturdy construction. A safety catch guards against accidental movement of toggle lever. *(Send for Data Sheet 134)*

SWITCH CHARACTERISTICS

Electrical rating at 30 vdc: inductive—10 amps. at sea level, 6 amps. at 50,000 ft.; resistive—10 amps.; motor—6 amps. Basic units listed by Underwriters' Laboratories for: 10 amps. 125 or 250 vac; ½ amp. 125 vdc; ¼ amp. 250 vdc.



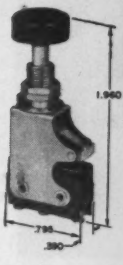
NEW!

MICRO SWITCH Magnetic Hold-in Lighted Pushbutton Provides Three Functions

MICRO SWITCH lighted pushbutton switch combines the functions of a three-pole double-throw pushbutton switch, indicating light, and holding relay into one compact unit which panel mounts on one-inch centers, both horizontally and vertically. Thus, the cost, wiring, maintenance and added space of these separate components are eliminated . . . A 28-volt dc solenoid is incorporated into the switch shaft. After the button is manually operated, the solenoid holds the switches in the operated position until electrically released. This feature gives the designer complete freedom in panel layout by eliminating the restrictions found in conventional mechanical release designs. *(Send for Data Sheet 128)*

SWITCH CHARACTERISTICS:

Operating force—35 oz. max. Pretravel—.050 in. approx. Total travel—.090 in. max. Three subminiature switches are SPDT.



NEW!

MICRO SWITCH "typewriter" pushbutton switch for manual keyboard control

MICRO SWITCH 1PB81-T2 switch is ideal for one-finger rapid-repeat operation such as is required for the type of keyboard control found in electric typewriters, adding machines, etc. The repeat action is as rapid as the fastest operator can push the button.

This switch uses a SPDT MICRO SWITCH subminiature switch for snap-action reliability. The contoured button and unique overtravel spring combine to reduce operator fatigue. Operating "feel," however, is sufficient to avoid mistakes and false actuations.

Removable ½ in. dia. plastic button is available in red, green, off-white or black. It is keyed to prevent rotation. *(Send for Data Sheet 125)*

SWITCH CHARACTERISTICS

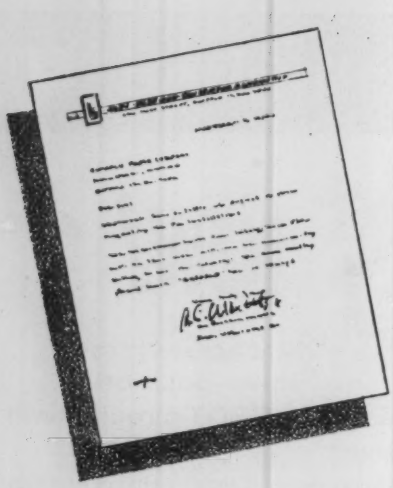
Electrical rating at 30 vdc: inductive—3 amps. at sea level and 50,000 ft.; maximum inrush—15 amps. Basic subminiature switch is listed by Underwriters' Laboratories at 5 amps. 125 or 250 vac.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

Circle 446 on Page 19



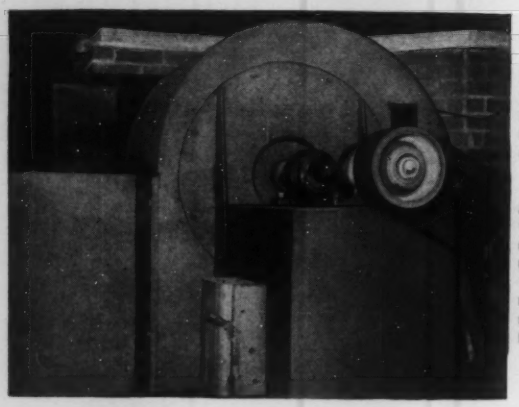
We would like to say that we are very well pleased with the "Buffalo" Fans we are using on our tunnel kiln installations. The "NV" Propeller Fan which Buffalo Forge designed for us for our drier operation is undoubtedly the best fan of this type we have used.

— from a leading manufacturer who builds "Buffalo" Fans into his products (name on request)

...and here's why

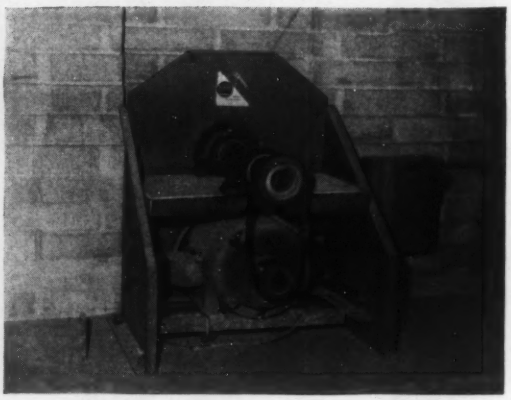
"BUFFALO" FANS WILL SUIT YOU, TOO

- HIGH EFFICIENCY
- STABLE PERFORMANCE
- COMPLETE SELECTION
- "SPECIAL" FANS ENGINEERED-TO-ORDER
- QUIET OPERATION
- DESIGN FLEXIBILITY
- "Q" FACTOR* RELIABILITY



At left — "Buffalo" Type "BL" Fan moving 14,000 cfm waste heated air from Tunnel Car Kiln to dryer.

At right — One of 3 "Buffalo" Dryer Recirculating Fans on Car Kiln. "Buffalo" "NV" Propeller Wheel mounted on end of shaft projected thru kiln wall.



INQUIRIES CONCERNING YOUR AIR HANDLING PROBLEM ARE INVITED.

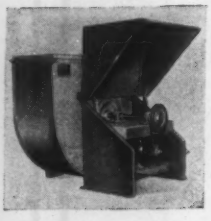
**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

BUFFALO FORGE COMPANY

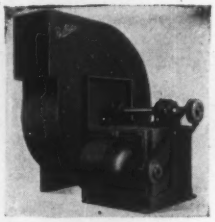
BUFFALO, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo" Volume Fans for blowing, exhausting jobs up to 10" s. p., have moisture-proof cast iron housings, dust-proof ball bearings.



"Buffalo" Belted Vent Sets are light-weight "packages" for small-system ventilation. Highly efficient and quiet. Write for Bulletins.



"Buffalo" All-Welded Industrial Exhausters handle any materials suitable for a pneumatic system. Heavy steel plate wheels and housings.

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Circle 447 on Page 19

hoover locks lube in, dirt out for the lifetime of the bearing

Hoover is first to seal ball bearings with TEFLON! Hoover makes *sure* that lube stays in, dirt stays away from the smooth, mirror-like working surfaces of high quality *Micro-Velvet* Lapped Balls and *Hoover Honed* Raceways. You get greatly extended bearing life.

Why TEFLON for seals? TEFLON is the remarkable new product of chemistry . . . extra tough . . . extra long wearing . . . and so slippery that there is practically no torque resistance. Hoover seals are ingeniously engineered to maintain positive contact and improve lube circulation. Permanently attached full metal shields lock the seals within the bearing, safe from damage.

Use Hoover Ball Bearings with single or double seals of TEFLON for high speed applications, electric motors, or wherever periodic lubrication or maintenance is not practical, as in sealed units. They are available in both light and medium series.

*TEFLON is DuPont's Trademark for its Fluorocarbon Resins.
Micro-Velvet and *Hoover Honed* are Hoover Trademarks.

hoover
BALL AND BEARING COMPANY
ANN ARBOR, MICHIGAN
SALES OFFICE AND WAREHOUSE: 2020 SOUTH FIGUEROA, LOS ANGELES 7, CALIFORNIA

OTHER HOOVER QUALITY BALL BEARINGS:
(light, medium, heavy series)

- Single and Double Shield
- Single Row Radial
- Combination Felt Seal and Shield
- Double Row
- Cartridge

NEW! BULLETIN 100—gives complete information on Hoover Bearings with Seals of TEFLON. To get your copy, just return the coupon below.

Hoover Ball and Bearing Company
Ann Arbor, Michigan

Please mail my copy of Bulletin No. 100 on Hoover Bearings with Seals of TEFLON.

Name_____
Title_____
Company_____
Address_____
City_____ State_____

MD-14

Note—Commercial and Military Packaging Engineers:

LINK-LOCK

...is the rugged answer to your exacting container closure problems

LINK-LOCK plays an important role in the design of this container

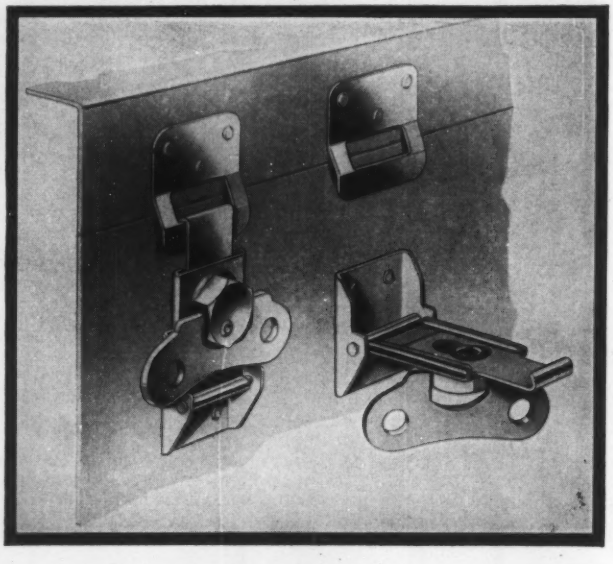
Courtesy of Pressurform Container Corp., and the LMEE Dept. of General Electric Co.

Simmons' LINK-LOCK provides pressure-tight, impact-resistant closure, plus quick closing and opening, on this reinforced fibrous plastic product made by the new automatic pre-form process developed by Pressurform Container Corp. The two-section container will be used by the Light Military Electronic Equipment Dept. of General Electric Company for shipping airborne radar jamming units to the Air Force.

Of prime importance are the container's lightness, strength, rust- and mildew-resistance, ability to withstand high pressures without distortion, ease of locking and opening, and low cost.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- High closing pressure with light operating torque... insures pressure-tight seals where required.
- Impact and shock resistant (positive-locking).
- Compact design...lays flat against case even when unlocked.
- Available in 3 sizes, for heavy, medium, and light duty.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.



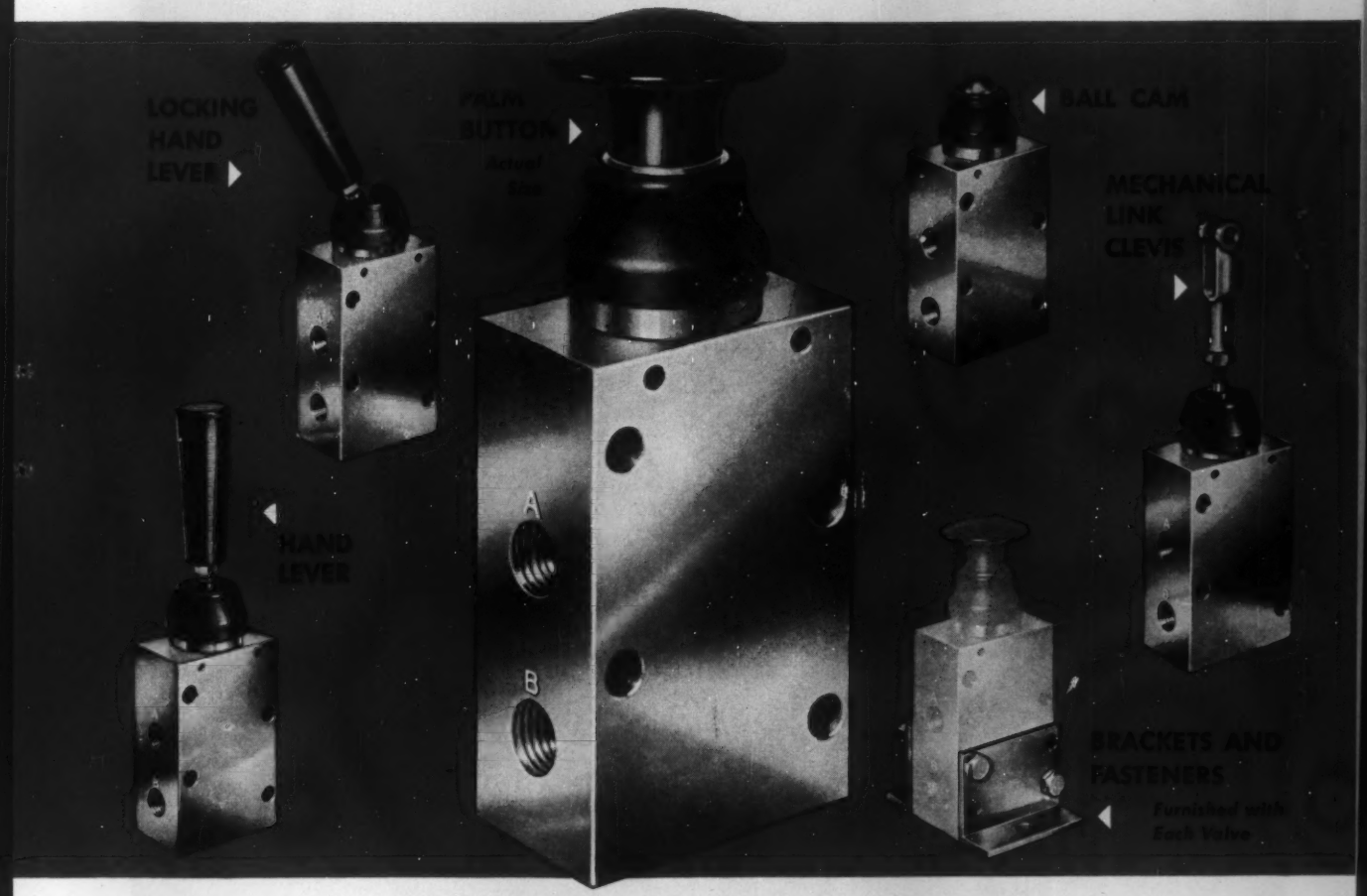
Also available! Spring-Loaded LINK-LOCK... ideal for less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

Where does the versatile Simmons LINK-LOCK belong in your design? For full information and specifications, send for LINK-LOCK DATA SHEETS today. Samples and engineering service available upon request.

SIMMONS
FASTENER CORPORATION
1756 North Broadway, Albany 1, New York
QUICK-LOCK SPRING-LOCK ROTO-LOCK LINK-LOCK DUAL-LOCK

Circle 449 on Page 19

NEW HANNA FLO-PILOT VALVE has dirt-proof seal!



Hanna Flo-Pilot Valves are ¼" two- and three-way Pilot Valves for air operation to 150 psi. They are used for remote control of master valves, directional control of small single acting cylinders and for shut-off. Same valve can be used for two or three-way operation either normally open or normally closed to inlet pressure.

HANNA Flo-Pilot Valves will deliver years of dependable performance at a very low cost because they have built-in money-saving features. Every Hanna Flo-Pilot Valve is equipped with a synthetic boot which seals the valve stem and internal parts from harmful dirt and abrasive, thereby eliminating the most common cause of valve failure.

These protective boots, efficient "O" ring spool packing and nylon sleeves, are built into every Hanna Flo-Pilot Valve to save you money and assure leak-free operation even after millions of cycles.

The five actuating-heads—push button, ball cam, hand lever, locking hand lever and mechanical link clevis—are interchangeable in a matter of seconds. Spools can be changed just as quickly without disturbing the piping.

Corrosion resistant materials are used throughout. Flo-Pilot Valves have a simple, sturdy construction with anodized aluminum body, stainless steel and molded nylon parts. Valves can be conveniently mounted in any position and are furnished with brackets and fasteners. They are easy to operate, positive acting and have full capacity of ¼" orifices.

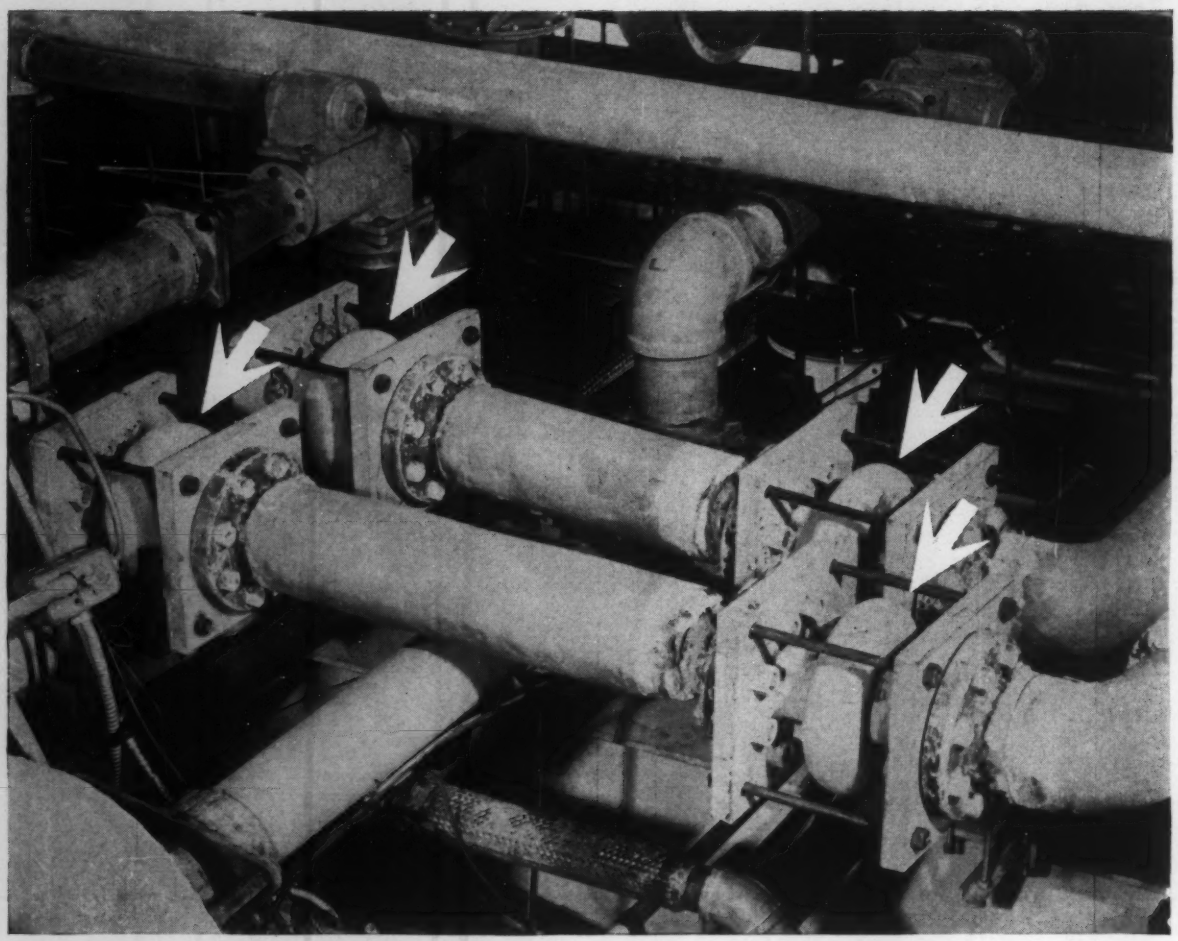
Ask your Hanna representative (see the yellow pages or Thomas Register) for complete information or *write direct for Catalog 262.*

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

1751 Elston Avenue • Chicago 22, Illinois

Circle 450 on Page 19



"Only *Carpenter* Stainless Tubing gives us failure-proof service"

The manufacturer of these four truly maintenance-free packless expansion joints (shown by arrows, above) has tried other stainless tubing, but says Carpenter Stainless Tubing is the "only one that renders failure-proof service".

These joints absorb thermal expansion, operating at pressures up to 210 psi and temperatures up to 650°F. They are typical of expansion joints made from Carpenter Tubing which operate at pressures up to 10,000 psi or temperatures as high as 1800°F. Once installed, they have never been replaced. Some have been in service over 15 years. The quality and uniformity of Carpenter Stainless Tubing contributed greatly to the trouble-free fabrication and maintenance-free service of these joints.

If an extra measure of quality in stainless tubing and pipe can improve your products or operation, call your Carpenter Distributor. He's your nearby source of better stainless tubing and pipe.

MEMBER

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Carpenter

Stainless Tubing & Pipe

WHATEVER THE APPLICATION

you can improve your product with

GRAMIX®

(PRODUCT OF POWDER METALLURGY)

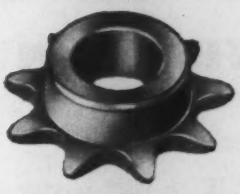
PRECISION FINISHED PARTS

GRAMIX precision finished parts are improving products in virtually every branch of industry. A pump manufacturer, for instance, may specify a gasoline pump rotor made of GRAMIX and gain a number of advantages.

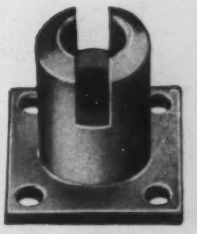
To begin with, the alloys are carefully blended to meet his individual requirements. The GRAMIX parts are then die-pressed to exact shape, sintered under rigid control and finished to tolerances as close as .0005". (This process, of course, costs far less than machining, forging or casting.) The manufacturer can expect the GRAMIX gasoline pump rotor to do a better job because *all* GRAMIX parts are precision engineered and precision controlled from alloying to finishing.

No matter what the application may be, GRAMIX parts fit specifications exactly. Parts may be impregnated with oil . . . to insure a longer life and a quieter operation: if specified, the GRAMIX parts may be coined and work hardened, even prepared for plating.

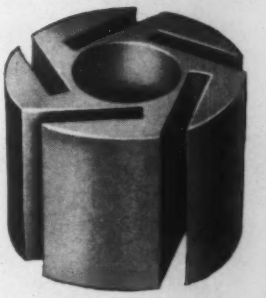
The rotor is only one of thousands of applications in which GRAMIX precision parts have proved to be ideal. Just a few of them are shown here, so consider the components of your products . . . there may be several that could be improved . . . with GRAMIX! Products of powder metallurgy you can rely on.



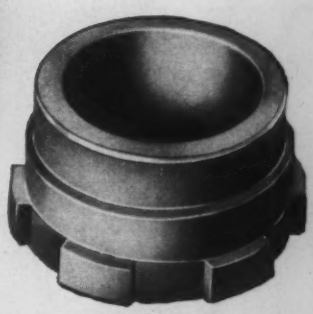
Hardened steel drive sprocket for lawnmower



Iron switch control

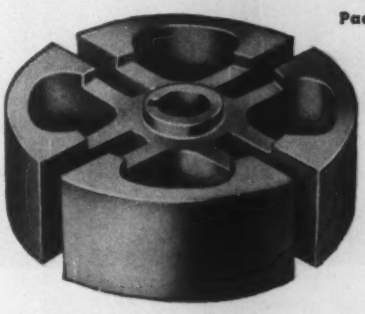


Rotor for gasoline pump



Packing gland follower used in hydraulic system

Write today for factual Engineering Bulletin No. 21 . . . we'll send your copy.



Bronze rotor in high speed fueling unit

X-245-1

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

TO PRODUCE QUALITY SOCKET SCREWS THE H-K WAY—

A NITROGEN GENERATOR FORMS A NEUTRAL ATMOSPHERE IN THIS CONTINUOUS HARDENING FURNACE

With this modern equipment, every H-K socket screw is uniformly heat-treated and tempered to provide exact tensile and torque specifications at all times. By carefully controlling the furnace atmosphere, we produce the distinctive, black H-K finish.

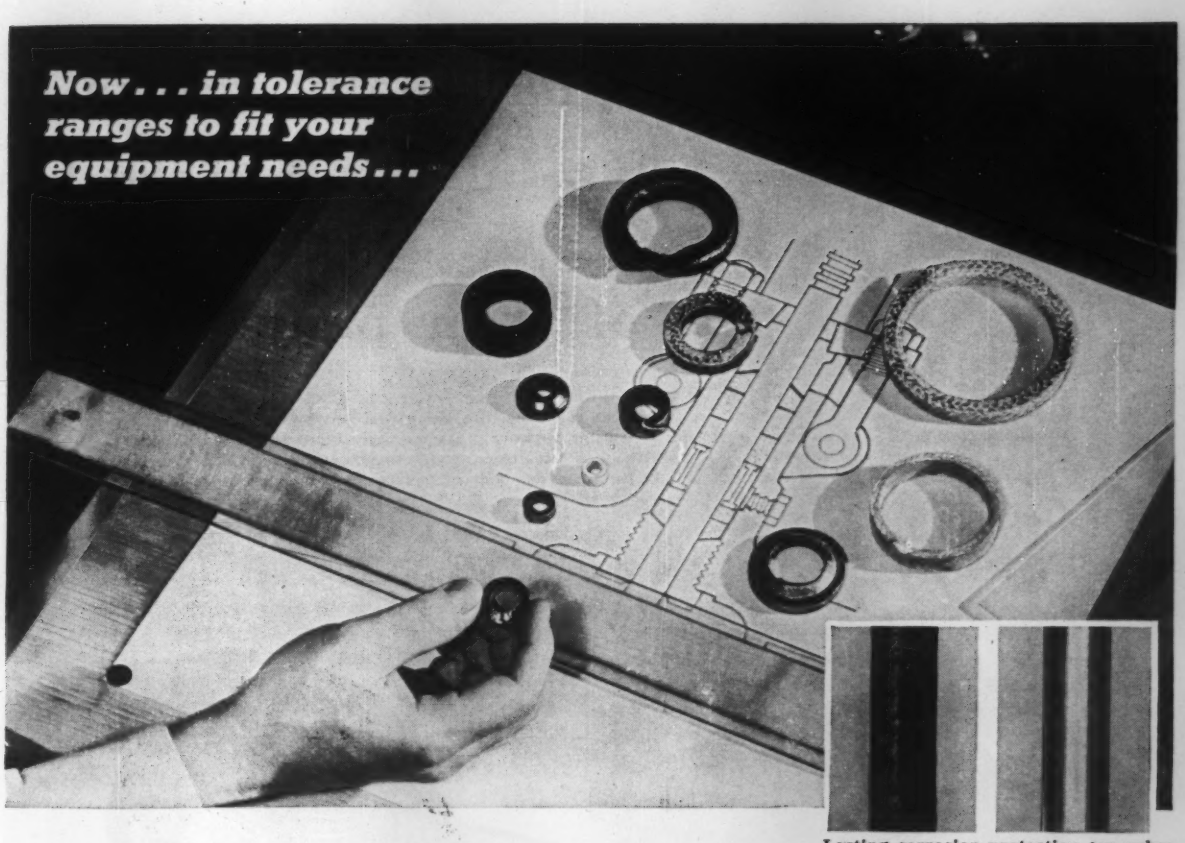
For the finest in socket screw products . . . for unmatched SAME-DAY SERVICE—the name to remember is Holo-Krome. Write for free catalog and technical information.

SOLD ONLY THROUGH AUTHORIZED HOLO-KROME DISTRIBUTORS

HOLO-KROME SOCKET SCREWS

THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

Circle 453 on Page 19



Lasting corrosion protection for valve stems in storage. Ordinary corrosion inhibitors fail to protect after the sacrificial metal is consumed. J-M No. 9 operates on an entirely different principle. Photograph shows how under accelerated tests, the sacrificial inhibitor (at left) failed after a few weeks *but the valve stem protected by J-M No. 9 (at right) was clean months later.* Specify J-M No. 9 inhibitor when you order J-M die-formed packing rings.

J-M Die-formed Packing Rings for all process fluids

Whether you are designing a bathroom fixture or a high-pressure valve, you can now choose your packing rings with greater certainty of both maximum sealability and easy assembly. For Johns-Manville has grouped its die-formed packing rings into three tolerance ranges—*dense, soft* and *metallic*—to fit your equipment needs.

Johns-Manville Die-Formed Packing Rings are precision-made for many fluid services including oils, tars, corrosives, solvents, fresh and salt water, steam to 1200 F, pressures to 4000 psi (on special valves to 60,000 psi). Special J-M rings with controlled friction are made for high-grade plumbing fixtures.

Check the tolerance chart below . . . your Johns-Manville Packing Representative will be glad to give you lists and descriptions of the styles in each range and those with which the J-M No. 9 Corrosion Inhibitor (*see right above*) may be specified or is standard. Write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

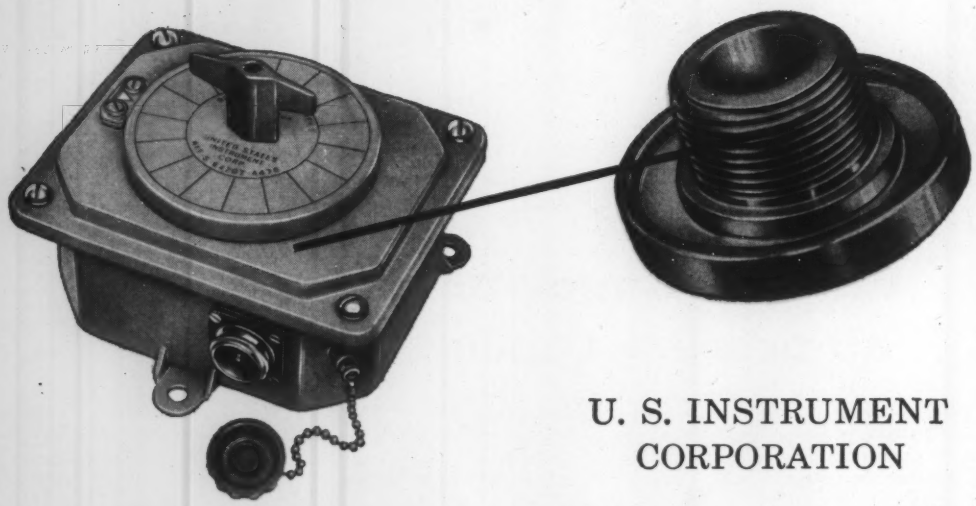
JOHNS-MANVILLE DIE-FORMED PACKING RING TOLERANCES	DENSE RINGS (including plastics)			SOFT RINGS (including cloth rings)			METALLIC RINGS		
	I.D.	O.D.	Depth	I.D.	O.D.	Depth	I.D.	O.D.	Depth
to and incl. ½″ O.D.	+.008″ −.000″	+.000″ −.008″	±1/64″	+.008″ −.000″	+.000″ −.015″	±1/64″	+.008″ −.000″	+.000″ −1/32″	±1/32″
Over ½″ to and incl. 1″ O.D.	+.008″ −.000″	+.000″ −.008″	±1/32″	+.008″ −.000″	+.000″ −.015″	±1/32″	+.008″ −.000″	+.000″ −1/32″	±1/32″
Over 1″ to and incl. 2⅜″ O.D.	+.008″ −.000″	+.000″ −1/64″	±1/32″	+.010″ −.000″	+.000″ −1/32″	±1/32″	+.008″ −.000″	+.000″ −1/32″	±1/32″
Over 2⅜″ O.D.	+.010″ −.000″	+.000″ −1/32″	±1/32″	+.010″ −.000″	+.000″ −3/64″	±1/32″	+.008″ −.000″	+.000″ −1/32″	±1/32″

Bevel (on all styles) ±5° when required

Johns-Manville PACKINGS, GASKETS and TEXTILES

Three more nationally known manufacturers select Mueller Brass Co. Forgeable Bearing Alloys for vital components of their products

In ever-increasing numbers, Mueller Brass Co. specialized alloys are being specified by manufacturers of top-quality products. In a series of continuing advertisements, we have presented case histories of successful applications, to which we now add three more distinguished companies who are incorporating Mueller Brass Co. forgeable bearing alloys in their products to meet the demands of widely divergent operating conditions.



U. S. INSTRUMENT CORPORATION

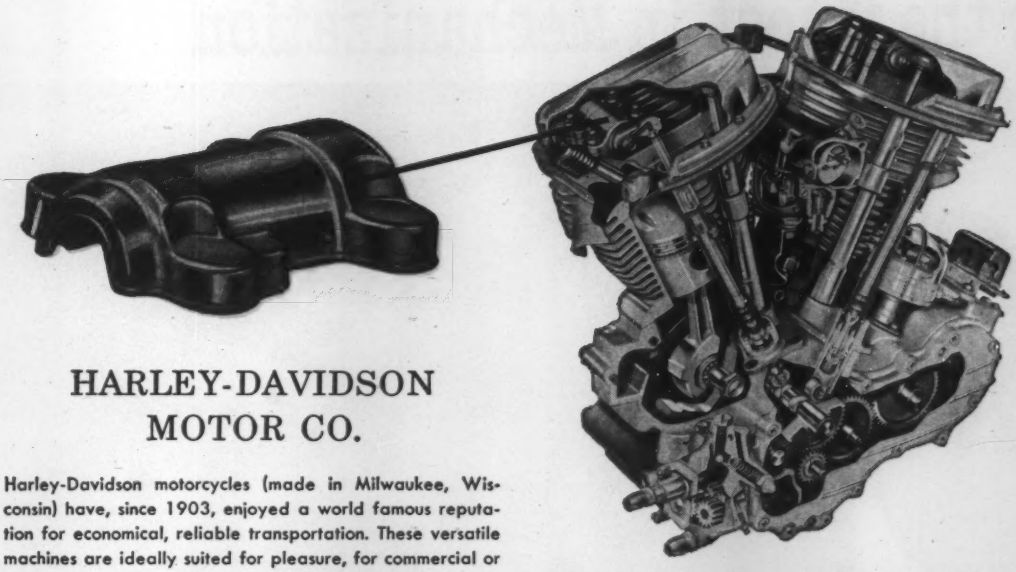
U. S. Instrument Corporation, Charlottesville, Va., selected abrasive-resistant Mueller bronze alloy bushings for their remarkable telephone selector switches after exhaustive tests of many materials. A vital communications link on today's U. S. Naval vessels, these sound-powered telephone circuits must meet rigid Navy performance-standards. Such phones, for example, must have selector switches which are capable of rotating for a minimum of 50,000 torturous cycles . . . 360° clockwise, followed by 360° counter-clockwise. In addition, the "O" ring must still form a water-tight seal AT THE END OF THE TEST! Of the many tested, a Mueller Brass Co. special manganese bronze alloy was the best one meeting these rigid specifications.

There were other important reasons why these bushings were chosen by U. S. Instrument Corporation for this application. Resistance to abrasive action against the rubber "O" ring was a prime one . . . then, too, the stem assembly suffered severe pounding through the action of the indexing mechanism which, prior to the use of the Mueller Brass Co. alloy, caused repeated seizure of the component parts. In this particular application, the part was fabricated on an automatic screw machine rather than produced as a forging. The versatility of Mueller Brass Co. alloys makes them readily adaptable to the most economical method of fabrication dependent upon the size, shape, and end-use requirements of the part.

In commenting on the success of this part, U. S. Instrument Corporation praised the alloy for its tensile strength (ordinary brasses could not withstand the 2000 ft. lb. impacts without deformation), for its machinability and corrosion-resistance.

40 OUR 40TH YEAR MUELLER BRASS CO. 1917-1957

MUELLER BRASS CO.



HARLEY-DAVIDSON MOTOR CO.

Harley-Davidson motorcycles (made in Milwaukee, Wisconsin) have, since 1903, enjoyed a world famous reputation for economical, reliable transportation. These versatile machines are ideally suited for pleasure, for commercial or business use, as well as the grueling demands of law enforcement work. Harley-Davidsons boast a dependable engine . . . one which can roll up an astounding mileage record with little or no care. The painstaking selection of every engine component is one important reason for this reliability. The new twin-cylinder Harley-Davidson 74 OHV employs Mueller Brass Co. bronze alloy forgings in the form of rocker-arm bearing caps. Subjected to violent temperature changes, fast starts and stops and road shock, Mueller forgings are proving again and again that they have the ability necessary to withstand almost any punishment . . . and still provide unfailing service.

JACOBSEN MFG. CO.

Jacobsen Mfg. Co., Racine, Wisconsin, was among the first to produce a practical power mower for home use. That was more than 35 years ago! Today, Jacobsen power-mower dependability is evident itself in more than a dozen gleaming new models such as the popular Pacer, Lawn Queen, Manor and others. One of the most reliable components in the always dependable Jacobsen hi-torque engine is a Mueller Brass Co. connecting rod forged from special bronze alloy. Jacobsen mowers with Mueller-forged connecting rods are called upon by some commercial users to operate as much as 8 hours daily, 6 days a week . . . perhaps as much as 2000 hours a year. In searing summer temperatures, thru hours of constant operation, the high uniform strength of Mueller bronze forgings constantly withstands pounding and vibration with the same conspicuous success as in its many other applications.

Why not investigate these specialized alloys for your own products. We welcome your inquiries. Our engineering staff will be happy to make specific recommendations. Both on the proper alloy and the best method of fabrication to meet your needs . . . exactly. Our engineering manuals show many, many examples of how American manufacturers have used these alloys to great advantage.

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

- **Mueller Brass Co. Forgings** Engineering Manual H-58565 ☐
- **Tuf Stuf Aluminum Bronze Alloys** Engineering Manual H-58563 ☐
- **"600" Series Bearing Alloys** Engineering Manual FM-3000 ☐
- **Copper Base Alloys in Rod Form** Engineering Manual FM-3010 ☐

227

P O R T H U R O N 2 0 , M I C H I G A N

For the finest in Mechanization

JEFFREY CHAIN

makes good equipment better

Chain for transmission of power—providing maximum strength with minimum weight, but with ample reserve strength to withstand sudden and heavy overloads. Chain for every elevating and conveying need—built for rigorous and continuous service under the most trying conditions.

Jeffrey offers a complete line of chain, with sprockets and attachments to suit. Equipment manufacturers from coast to coast rely on these Jeffrey products to give their equipment greater dependability. Plant operators employ them to hold down costs.

Jeffrey chain and accessories are stocked for your convenience by your Jeffrey distributor. For help in selecting chain for any job, call them or get in touch with The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

We can help you with modern, efficient equipment for Materials Handling • Chain Applications • Materials Reduction • Processing • Sanitation • Mining... and with a contract engineering-manufacturing service for your products. Jeffrey guarantees your enthusiasm!

JEFFREY

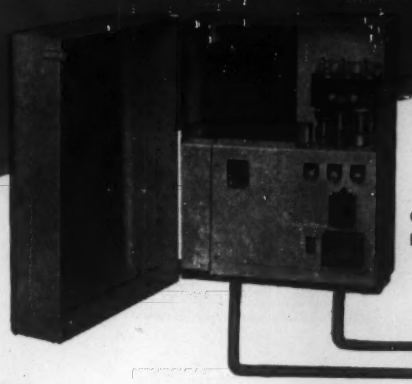
Founded in 1877

THE JEFFREY MANUFACTURING COMPANY • COLUMBUS 16, OHIO

Circle 456 on Page 19

DYNAMATIC®

Drive Package Provides Infinitely Adjustable Speeds from AC Power Source



CONTROL PANEL

CONTROL STATION

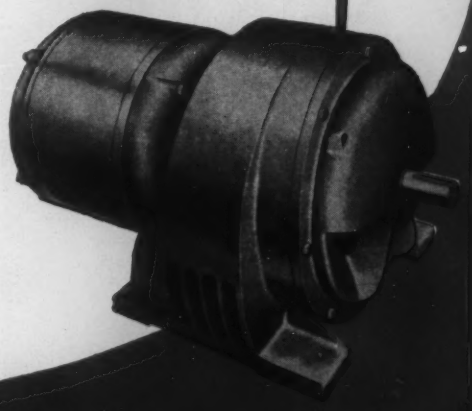
The complete Dynamatic power package includes all components required to provide infinitely adjustable speeds from an alternating current power source. A Dynamatic Ajusto-Spede® or Dynaspede® Drive, with electronic control and pushbutton station, satisfies the requirements of almost any application where proper machine operation or material processing depends upon control of operating speeds.

The compact control panel may be remotely mounted to conserve valuable space on the driven machine. The pushbutton station at the operator's position puts vital controls conveniently at the operator's fingertips and requires a minimum of space.

Speeds are infinitely adjustable from 0 RPM to full output speed, and accurate speed regulation may be obtained from 100 RPM to full output speed.

Ajusto-Spede® Drives, available in ratings of 1/4 horsepower to 75 horsepower, are air-cooled. Dynaspede® Drives, rated from 3 to 75 horsepower, are liquid-cooled. Raise your productive efficiency with Dynamatic eddy-current units.

DYNAMATIC®
AJUSTO-SPEDE DRIVE



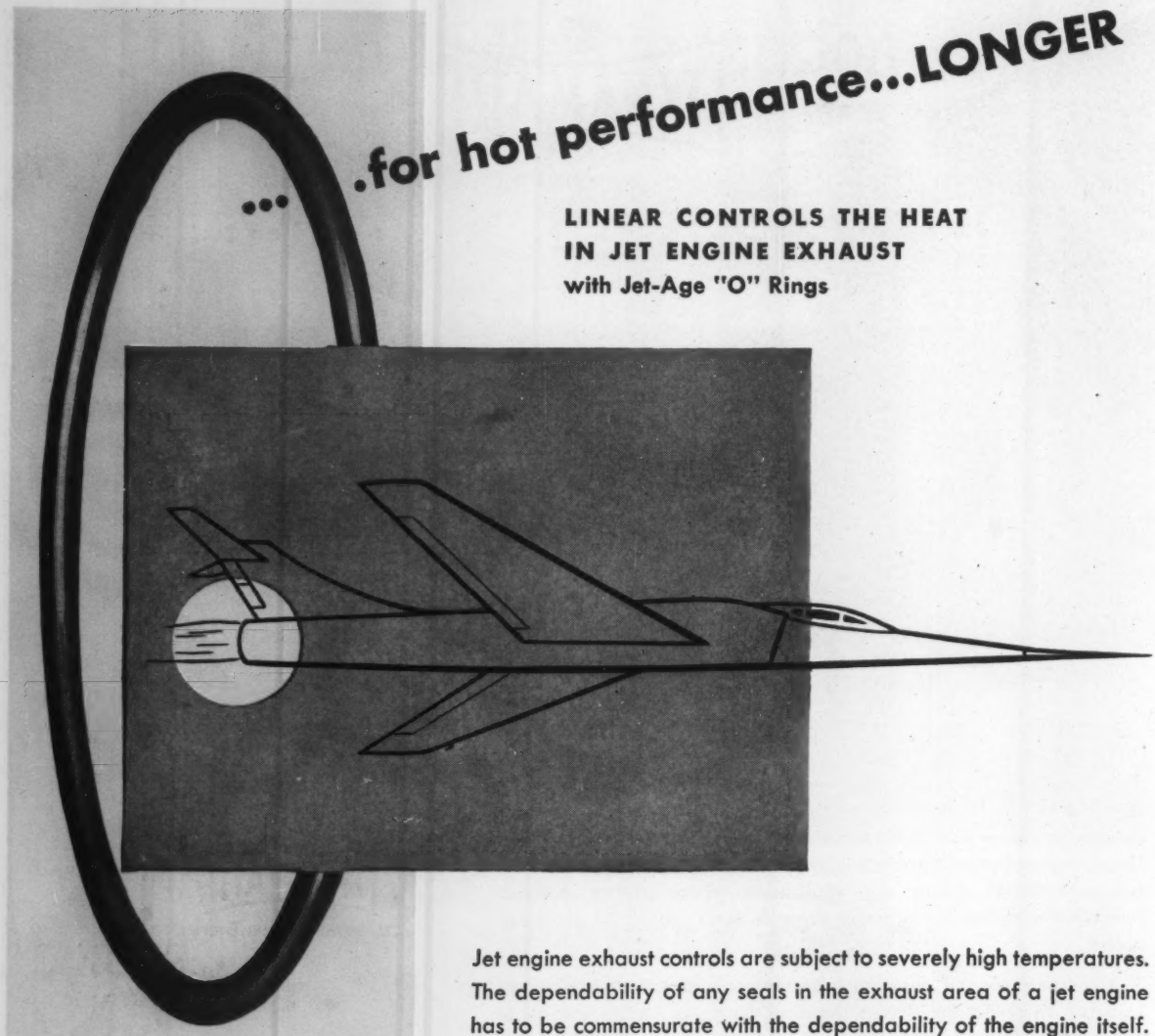
Send for Illustrated Literature Describing Dynamatic Adjustable Speed Drives

EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

...for hot performance...LONGER

LINEAR CONTROLS THE HEAT IN JET ENGINE EXHAUST
with Jet-Age "O" Rings



Jet engine exhaust controls are subject to severely high temperatures. The dependability of any seals in the exhaust area of a jet engine has to be commensurate with the dependability of the engine itself.

LINEAR'S ability and extensive experience in the design and manufacture of precision "O" rings—in such modern, heat-resistant elastomers as the silicone family—makes this kind of dependability a reality. LINEAR "O" rings, capable of withstanding intermittent ambient temperatures as high as 1000° F—and the destructive actions of gases and fluids, help control the jet engine exhaust—for hot performance—longer.

For a sealing problem of any kind—call on LINEAR or one of its agents for engineering assistance...

and be sure to Specify LINEAR "O" Rings for every application.

"PERFECTION IN RUBBER"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

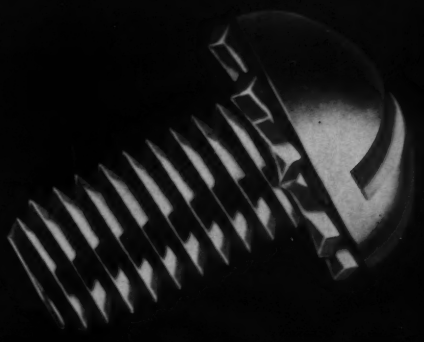
Circle 458 on Page 19

Pre-assembled

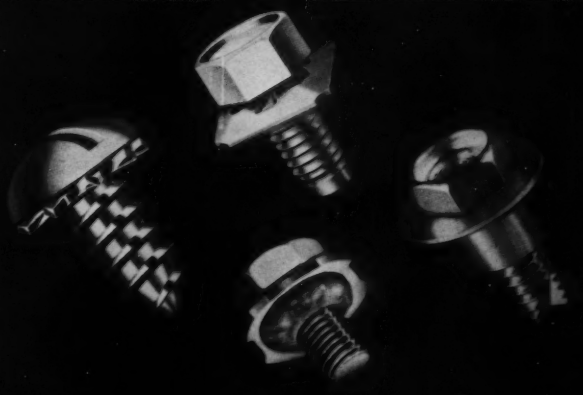
to cut your

Costs

...by eliminating handling of multiple parts



SEMS-BY-SHAKEPROOF
Pre-assembled Screw
and Shakeproof® Lock Washer



Even greater cost-savings are possible with Sems-by-Shakeproof through variations in threads, points, heads, and washers, or with the addition of sealing compound or special sleeves.

• You handle one unit instead of two or more with Sems-by-Shakeproof • Every lock washer is factory-matched • Lost and forgotten washers eliminated • Available in variety of screw and lock washer combinations, multiple-piece assemblies and with mastic sealants.

Send for Sems-by-Shakeproof sample kit today

SHAKEPROOF

"FASTENING HEADQUARTERS"®

DIVISION OF ILLINOIS TOOL WORKS

St. Charles Road, Elgin, Illinois • Offices in Principal Cities
In Canada: SHAKEPROOF-FASTEX, Division of Canada Illinois Tools, Ltd., Toronto, Ontario

itw

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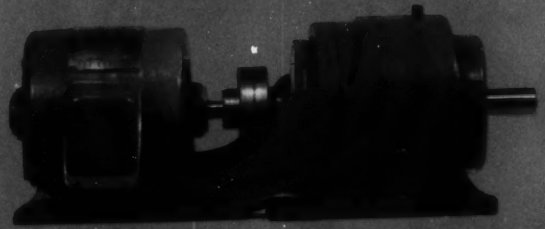
Circle 460 on Page 19→

A great gear-motor

NEW integral unit

Compact, one-piece unit has complete, easily removable motor, machined-in alignment.

NEW all-motor unit



Providing wide application flexibility, motor change may be accomplished without disturbing gear.

General Electric's NEW gear-motor line

Now, you can meet all your low-speed drive requirements from a brand new line of General Electric packaged power transmissions. This 3-unit line is based on a new, completely simplified, helical design that has evolved from General Electric's 25 years of gear-motor engineering and application experience. And it's a line that can provide you with important, 3-way savings on all low-speed applications.

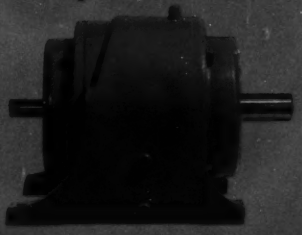
1. **Greater reliability:** This new line incorporates the most advanced gear manufacturing methods and all units are factory tested before shipment. In addition, you benefit because you purchase both motors and gears from a single manufacturer.

2. **Easier Maintenance:** A cinch to assemble and disassemble, alignment is machined right into each unit. Gear components may be carried in stock as sub-assemblies, minimizing downtime for normal repair.

3. **Reduced inventory:** You can reduce your inventory with no sacrifice to your operating continuity. Parts standardization and interchangeability permit a basically lower inventory investment.

This new line was developed to keep pace with the new requirements and wider applications of gear-motors brought about by advanced manufacturing techniques. *Get complete information from your nearest Apparatus Sales Office or Distributor—or write for bulletin GEA-6704, containing line highlights, to General Electric Co., section 851-6, Schenectady, N. Y.* Gear-Motor and Transmission Components Dept.

NEW separate reducer



Unit can provide a variety of output speeds with change of belt or chain rates.

Progress Is Our Most Important Product

GENERAL ELECTRIC

See what adhesives are doing today!

A MODERN FASTENER SPEEDS THIS ASSEMBLY LINE. IT NEEDS NO HOLES, BONDS PARTS INSTANTLY. IT'S 3M ADHESIVE EC-1357.

Simplifying the assembly line

A 3M adhesive is helping to create 50 shelves per hour right before your eyes. By bonding parts instantly, EC-1357 simplifies this assembly line to just four fast operations.

One worker puts metal frames and fiberboard sheets on a conveyor moving 9 feet per minute. The second sprays EC-1357 on both as they pass by. The third positions the boards on the frames. They pass under a pressure roller and the bond is complete. There are no extra fastening steps.

Instantly EC-1357 bonds board to frame so strongly that the fiberboard will delaminate if you try to remove it. A fourth man installs molding. The shelves are ready to ship immediately.

Hundreds of other 3M adhesives serve industry in a thousand varied uses.

SEE WHAT ADHESIVES CAN DO FOR YOU!

Learn how 3M research can speed your production, cut your costs. Consult your 3M Field Engineer. For a free booklet and more information write: 3M, Dept. 1012, 417 Piquette, Detroit 2, Mich.

PRODUCT OF 3M RESEARCH

3M ADHESIVES

ADHESIVES AND COATINGS DIVISION, **MINNESOTA MINING AND MANUFACTURING COMPANY**

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MAKERS OF "SCOTCH" BRAND PRESSURE-SENSITIVE ADHESIVE TAPES • "SCOTCH" BRAND SOUND-RECORDING TAPE • "SCOTCHLITE" BRAND REFLECTIVE SHEETINGS • "3M" ABRASIVE PAPER AND CLOTH • "3M" ADHESIVES AND COATINGS • "3M" ROOFING GRANULES • "3M" CHEMICALS

Quality is a *must* for trouble free operation, continued customer satisfaction. And quality depends upon the excellence of every part, every component. For many years Whirlpool-Seeger has used OILITE center post bearings, agitator shaft bearings, water pump bearings and pulley bearings in their automatic washers. Whirlpool-Seeger uses these and other OILITE parts for very good reasons.

First of all, the manufacturer knows OILITE heavy-duty bronze bearings will meet specifications. Chrysler-Amplex precision production assures him OILITE bearings capable of carrying their loads safely, surely and quietly.

Then too, Chrysler-Amplex plant and facilities—largest and most complete of any in the metal powder fabrication industry—promises on-time deliveries in any quantity.

Moreover, in using OILITE bearings the manufacturer selects a product his customers know and respect for superior engineering.

Finally, this manufacturer, like a great many others, finds OILITE bearings—despite all their advantages—cost no more.

Chrysler-Amplex representatives and dealers are located in principal cities in United States and Canada. Let the nearby representative help you. Find him in the yellow section of your telephone directory under—"Bearings—OILITE."

A CHRYSLER OILITE PRODUCT

*OILITE is a registered trademark

*Only Chrysler Makes Oilite**

AMPLEX DIVISION

CHRYSLER CORPORATION • DETROIT 31, MICHIGAN

Representatives and dealers located throughout the world

BEARINGS • FINISHED MACHINED PARTS • PERMANENT METAL FILTERS • FRICTION UNITS • FERROUS AND NON-FERROUS METALS

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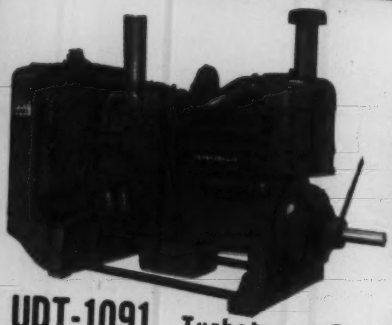


UDT-1091 Turbotorque® Diesel 6-cyl; 5¾ x 7; 1,091 cu. in. displ.; Eng. hp @ 1500 rpm: Max. 300; int. 265; Power Unit Int. load hp —250 @ 1500 rpm

UD-1091 6-cyl Diesel 5¾ x 7; 1,091 cu. in. displ.; Eng. Max. hp—224 @ 1500 rpm; Power Unit Int. load hp—202 @ 1500 rpm

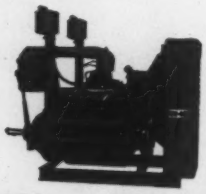
UD-18A 6-cyl Diesel 4¾ x 6½; 691 cu. in. displ.; Eng. Max. hp—150 @ 1600 rpm; Power Unit Int. load hp —125 @ 1600 rpm

U-501 6-cyl Carbureted 4½ x 5¼; 501 cu. in. displ.; Basic Eng. Max. hp: Gaso.—212 @ 3000 rpm; Power Unit Net hp: Gaso. — 133 @ 2200 rpm; LPG—128 @ 2200 rpm

U-450 6-cyl Carbureted 4⅜ x 5; 450 cu. in. displ.; Basic Eng. Max. hp — Gaso. — 182 @ 3000 rpm; Power Unit Net hp: Gaso. — 126 @ 2200 rpm; LPG—124 @ 2200 rpm

U-372 6-cyl Carbureted 4⅜ x 4⅛; 372 cu. in. displ.; Basic Eng. Max. hp—Gaso.—165 @ 3200 rpm; Power Unit Net hp: Gaso. — 104 @ 2200 rpm; LPG—97 @ 2200 rpm

UV-549 V-8-cyl Carbureted 4½ x 4¾; 549 cu. in. displ.; Eng. Max. hp: Gaso. — 257 @ 3400 rpm; Power Unit Net hp: Gaso. — 208 @ 2600 rpm; LPG—201 @ 2600 rpm

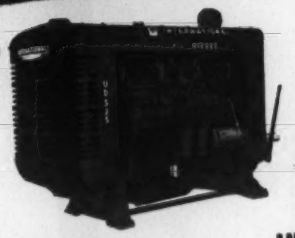


UV-461 V-8-cyl Carbureted 4⅛ x 4¾; 461 cu. in. displ.; Eng. Max. hp: Gaso. — 226 @ 3600 rpm; Power Unit Net hp: Gaso. — 169 @ 2600 rpm; LPG—169 @ 2600 rpm

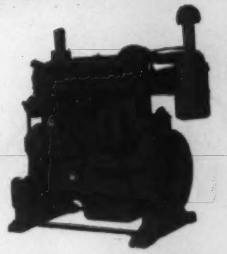
UV-401 V-8-cyl Carbureted 4⅛ x 3¾; 401 cu. in. displ.; Eng. Max. hp—Gaso.—206 @ 3600 rpm; Power Unit Net hp: Gaso. — 155 @ 2800 rpm; LPG—155 @ 2800 rpm

Power that protects your reputation as a specifier!

Call in THE MAN FROM INTERNATIONAL for the full story on 20 heavy-duty industrial engines that deliver a full measure of dependable power

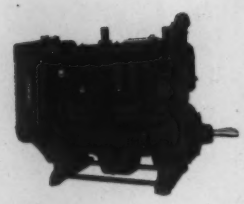


UD-525 6-cyl Diesel
4½ x 5½; 525 cu. in. displ.; Eng. Max. hp—137 @ 2000 rpm; Power Unit Int. load hp—115 @ 1800 rpm



UD-14A 4-cyl Diesel
4¾ x 6½; 461 cu. in. displ.; Eng. Max. hp—105 @ 1800 rpm; Power Unit Int. load hp—76 @ 1400 rpm

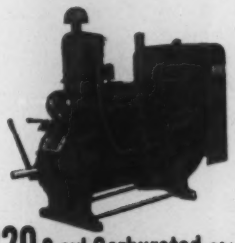
UD-350 4-cyl Diesel
4½ x 5½; 350 cu. in. displ.; Eng. Max. hp—92 @ 2000 rpm; Power Unit Int. load hp—75 @ 1800 rpm



UD-281 4-cyl Diesel
4⅛ x 5¼; 281 cu. in. displ.; Eng. Max. hp—68 @ 1800 rpm; Power Unit Int. load hp —60 @ 1800 rpm

U-308 6-cyl Carbureted 3 13/16 x 4½; 308 cu. in. displ.; Basic Eng. Max. hp—Gaso.—154 @ 3600 rpm; Power Unit Net hp: Gaso.—87.5 @ 2400 rpm; LPG —91.2 @ 2400 rpm

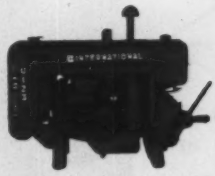
U-264-6 6-cyl Carbureted 3 11/16 x 4⅛; 264 cu. in. displ.; Basic Eng. Max. hp — Gaso. 153 @ 3700 rpm; Power Unit Net hp: Gaso. — 78 @ 2400 rpm; LPG—81 @ 2400 rpm



U-220 6-cyl Carbureted 3 11/16 x 3 11/16; 220 cu. in. displ.; Basic Eng. Max. hp: Gaso. — 112 @ 3700 rpm; Power Unit Net hp: Gaso.—68 @ 2400 rpm; LPG—68 @ 2400 rpm

U-281 4-cyl Carbureted
4⅛ x 5¼; 281 cu. in. displ.; Power Unit Net hp: Gaso. — 67.5 @ 1800 rpm; LPG—73 @ 1800 rpm

U-175 4-cyl Carbureted
3⅝ x 4¼; 175 cu. in. displ.; Power Unit Net hp: Gaso. — 50 @ 2000 rpm; LPG—51.5 @ 2000 rpm



U-123 4-cyl Carbureted
3⅛ x 4; 123 cu. in. displ.; Power Unit Net hp: Gaso.—33 @ 2000 rpm; LPG—27.5 @ 2000 rpm

UC-60 4-cyl Carbureted
2⅝ x 2¾; 60 cu. in. displ.; Power Unit Net hp: Gaso.—16.5 @ 2500 rpm; Nat. gas —13.5 @ 2500 rpm

Here you see the complete expanded 20-model line of International power—heavy-duty engines and power units that continue to justify the judgment of men who have specified International for more than 50 years.

Choose any of the 13 carbureted industrial engines, from 16 to 257 hp, or seven diesels, from 60 to 265 intermittent load hp, with full confidence. You'll always get an engine that delivers a full measure of dependable, economical power. And every engine is backed by the finest parts and service support in the world.

For full details on engines of interest to you, call in THE MAN FROM INTERNATIONAL. You'll find him as helpful as the power he sells will be profitable to your customers. Through him you can get assistance with all installation problems, including pilot model engines, and very special delivery service when you need it. Just call his headquarters in Melrose Park, Illinois—Fillmore 3-1800.

INTERNATIONAL® CONSTRUCTION EQUIPMENT

International Harvester Co., 180 N. Michigan Avenue, Chicago 1, Illinois

A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.

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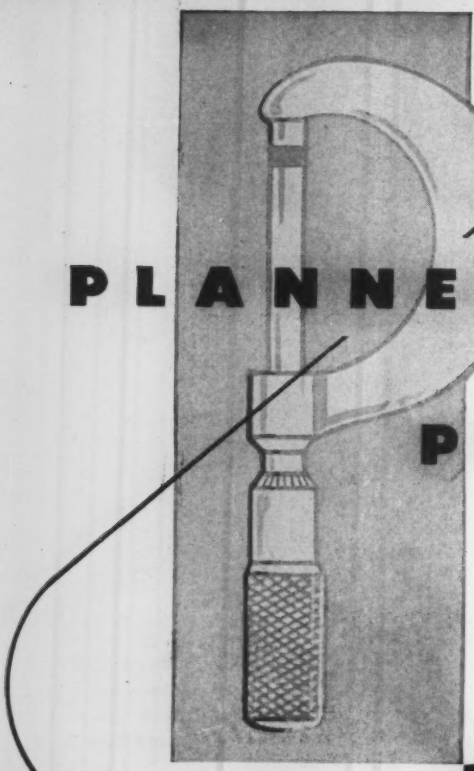
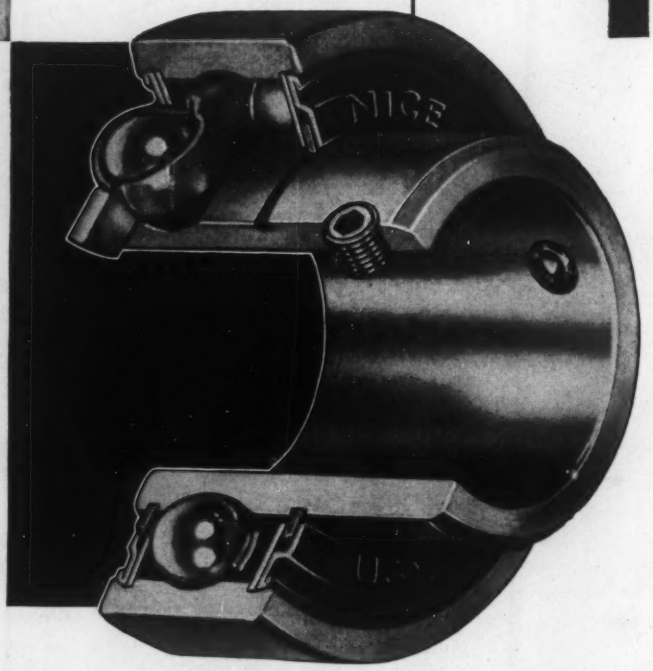
PLANNED PRECISION





In a bearing, **PLANNED PRECISION** is the carefully evaluated incorporation of whatever precision features are necessary to provide for the functional requirements of the job—not more, not less. Precision refinements are costly, and should be selected with care to insure products that are both economically and functionally correct.

In the **NICE LINE**, Product Designers will find a complete range of ball bearings incorporating varying degrees of precision. NICE catalog standard bearings are available in precision, semi-precision and unground types. If a specially designed bearing is the correct answer to the application problem, NICE engineers are qualified and capable "Specialists in Specials".

Write for Catalog No. 190

NICE

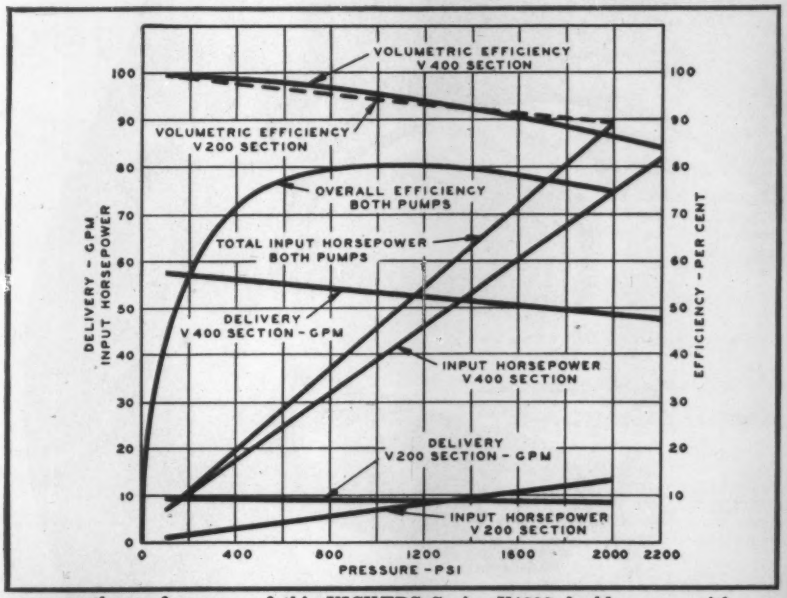
NICE is the word for **BEARINGS**

NICE BALL BEARING COMPANY
NICETOWN · PHILADELPHIA · PENNSYLVANIA

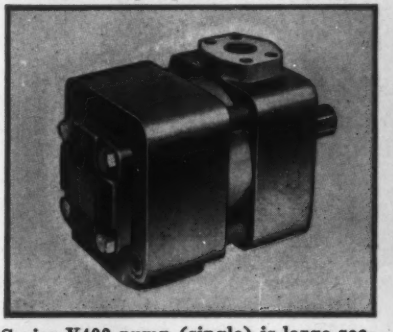
Circle 464 on Page 19

On tractor shovels, scrapers, lift trucks, truck cranes, bulldozers, motor graders, front end loaders, ditchers, trucks, buses and many other types of mobile equipment . . .

The *High Efficiency* of Vickers Balanced Vane Pumps Means *More* Work From *Less* Input Power



COMPARE the performance of this VICKERS Series V4200 double pump with any other hydraulic pump used on mobile equipment. The high overall efficiency in the operating pressure range is maintained throughout the long pump life (see right hand column for reasons). This performance is characteristic of all Vickers Vane Pumps . . . both single and double. (Above curves are in accordance with SAE test code except speed is 2000 rpm.)



Series V400 pump (single) is large section of double pump at right; performance characteristics are shown above. In addition to the advantages mentioned in the right hand column, Vickers Vane Pumps require minimum maintenance and are exceptionally compact. Their various mountings and optional pressure outlet connection positions provide greater application versatility. See pages 4-5, Bulletin M5101A.

Series V4200 double pump for operating two independent hydraulic circuits from one power source. In numerous mobile applications, this is desirable to eliminate all possible chance of one operation interfering with another . . . when necessary to operate two machine components simultaneously at different speeds and hydraulic pressures. See pages 6-7, Bulletin M5101A.

You can get more useful work out of a given engine when a Vickers Balanced Vane Pump is used in the hydraulic control system. Its exceptionally high volumetric and overall efficiency are available not only when the pump is new but also throughout its long life.

The performance curves at the left merit your careful consideration. Note that the overall efficiency is approximately 80% at operating pressures used. Compare this with the rapid decline in overall efficiency of the usual gear pump at higher pressures. This large difference means a very substantial saving in engine horsepower and fuel consumption. To do a given job, it often means that a smaller engine can be used. It further means less heating of the oil.

Vickers Balanced Vane Pumps have many other benefits for the user. Optimum running clearances are automatically maintained over the entire operating pressure range and throughout an exceptionally long pump life. Complete hydraulic balance eliminates pressure-induced bearing loads. Other bonuses are: automatic wear compensation, temperature adaptability, simple installation, and easier cold weather starting.

Millions of Vickers Vane Pumps are in daily use. For further information, write for Bulletin M5101A. 7856

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Mobile Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
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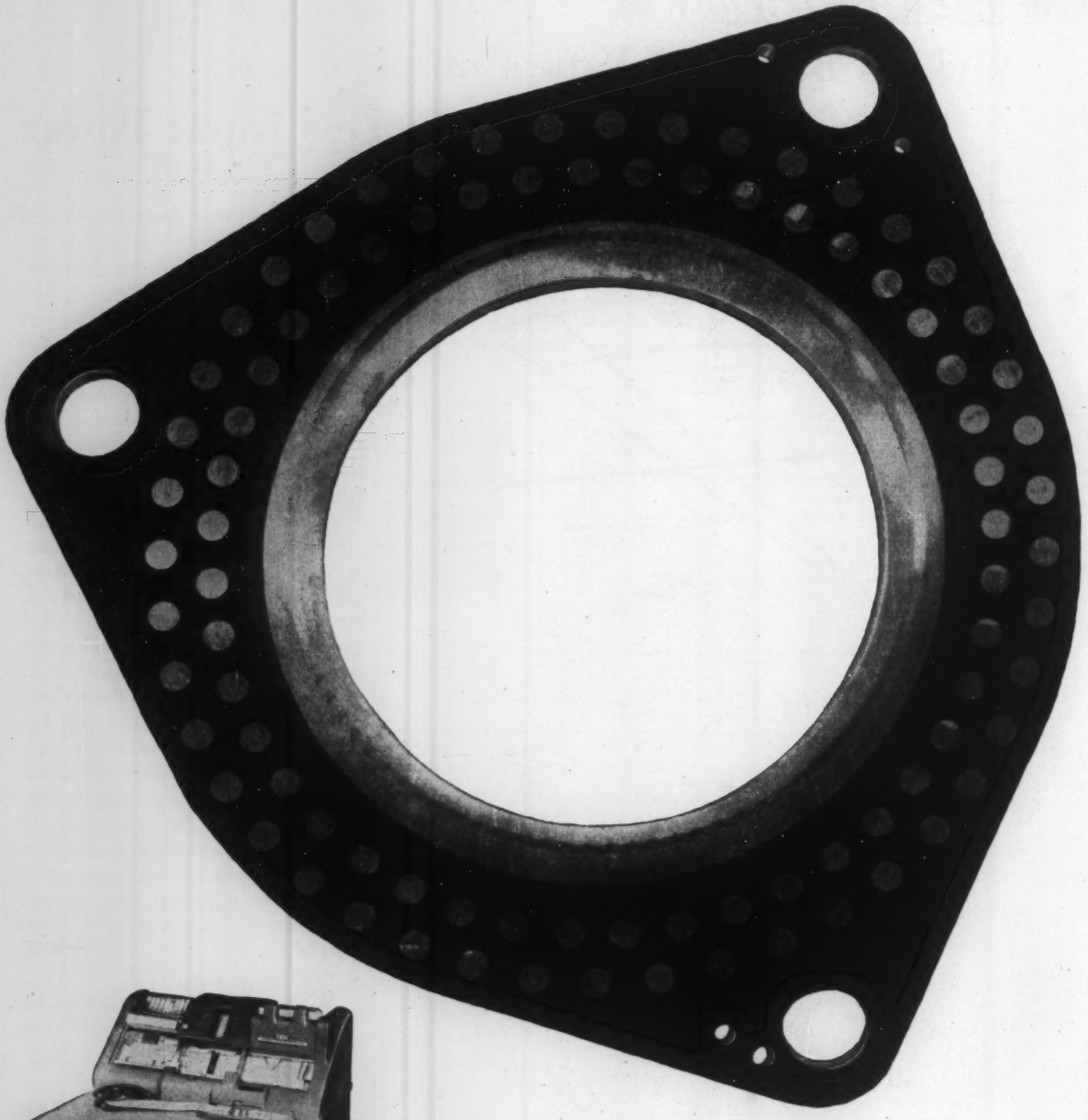
In Canada: Vickers-Sperry of Canada, Ltd., Toronto & Montreal

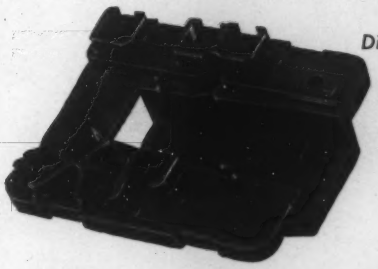
When one of many requirements is **DIMENSIONAL**



DIMENSIONAL STABILITY, resistance to wear, and freedom from carbonization were required in this 88-insert stator in the emitter assembly of the IBM 46 Tape-to-Card Punch. Stator is Durez diallylphthalate, has inserts and center ring molded in.

STABILITY...

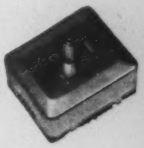
get the others too... with

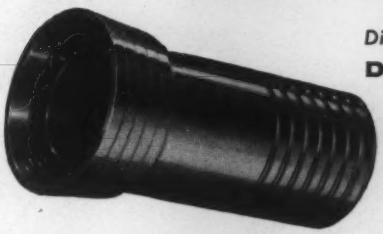


Dimensional Stability plus

HEAT RESISTANCE

These, combined with fine electrical properties, make Durez phenolics preferred for countless applications. Illustrated: mounting base for King-Seeley's new Chef-O-Matic range surface element temperature control.

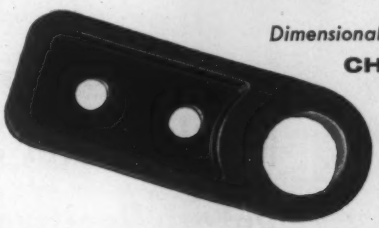




Dimensional Stability plus

DURABLE SURFACE LUSTER

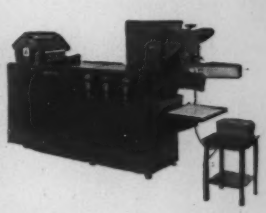
Smooth operation of the lens tube on the Wollensak Automatic Slide Projector is assured by molded-in threads that meet exacting tolerances. It's engineered for attractive appearance in lustrous black Durez phenolic.



Dimensional Stability plus

CHEMICAL RESISTANCE

Print conveyor bearings molded of nylon-flock-filled Durez phenolic operate submerged in Photostat Photographic Processors, withstand the effects of processing solutions and the wear of rotating metal shafts.



DUREZ PLASTICS

It's obvious that you just can't stop with one outstanding property—or even two or three—when you're looking for a plastic to solve a design problem... improve a product...hold the cost line. This is why the Durez thermosetting plastics are a gold mine of ideas for design engineers.

Durez offers balanced properties in a great variety of useful combinations.
For close-tolerance components resistant to impact, heat, water and chemicals...and wherever good electrical characteristics are essential... count on success with Durez phenolics. Their batch-to-batch uniformity and excellent molding behavior permit design in intricate shapes and hold down cost. Many are formulated for easy preforming and molding in automatic machines.

Where very high volume resistivity and arc resistance are required, investigate the Durez diallylphthalate materials.

For data and information keep in touch with your molder...call on our field engineering service...or let us send you our monthly "Plastics News."

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Plastics that Fit the Job

DUREZ PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY

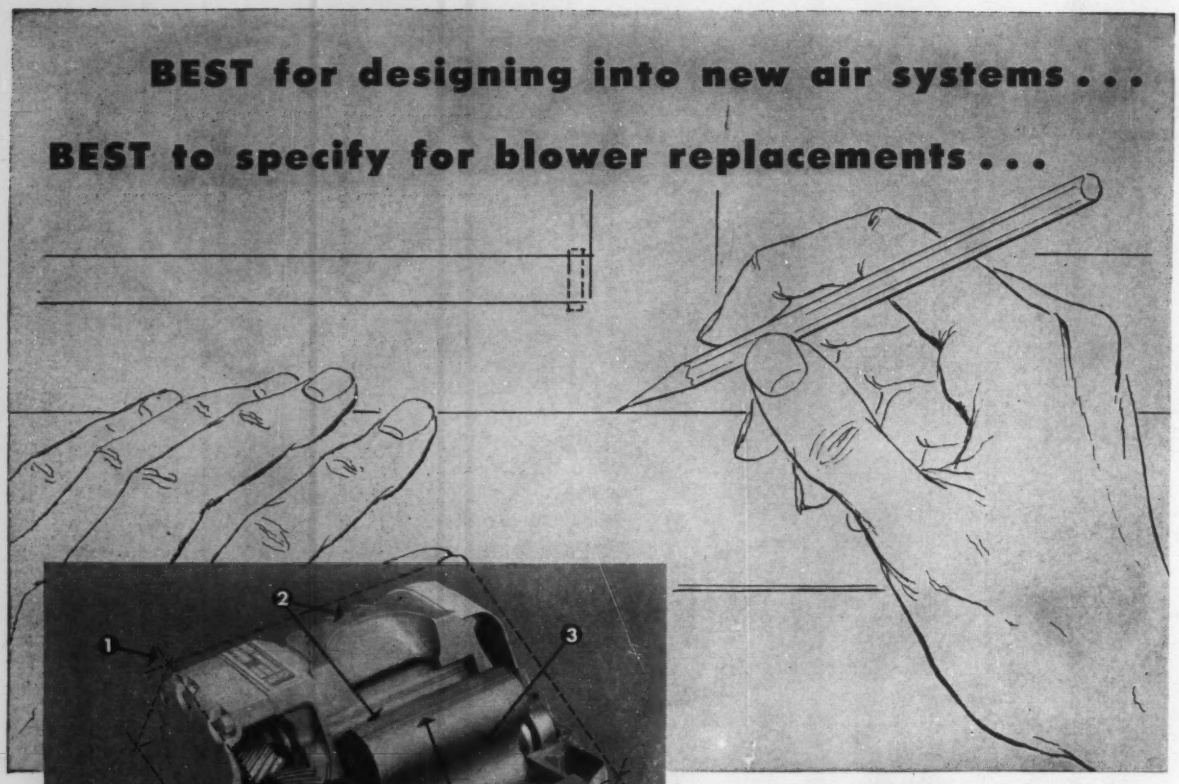
512 WALCK ROAD, NORTH TONAWANDA, N. Y.

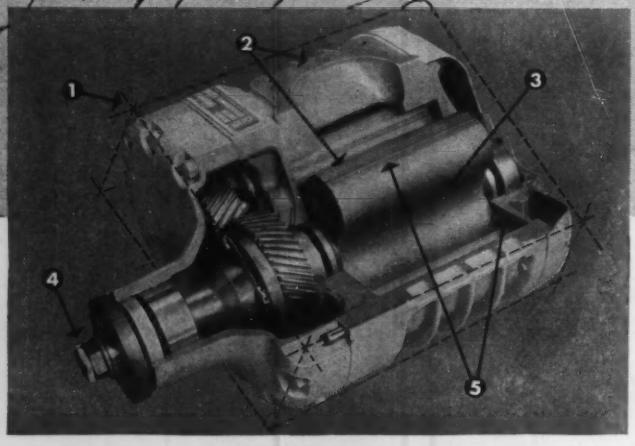
HOOKER CHEMICALS PLASTICS

Circle 466 on Page 19

BEST for designing into new air systems . . .

BEST to specify for blower replacements . . .





THERE'S A BIG DIFFERENCE WITH

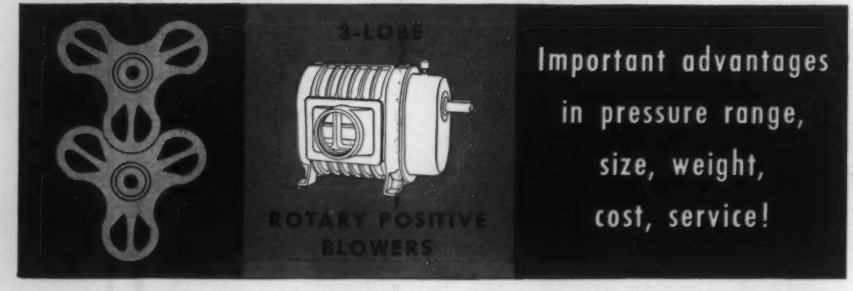
Miehle-Dexter 3-Lobe Rotary Positive Blowers

① **Smallest Cube** OF ALL ROTARY POSITIVE BLOWERS
② **Lightest Weight** WITH ALUMINUM ROTORS AND HOUSING
③ **Wide Pressure Range** 1 TO 12 PSIG
④ **Wide Speed Range** 1000 TO 4000 RPM
⑤ **Exclusive Formica Wear Strips** ON ROTORS
Patented Rubber Grid Seal ON END PLATE

When specifying components for new air systems, or for replacements in existing systems, size and weight considerations are important if maximal space utilization is to be realized. When it comes to size and weight considerations for blowers, none compare with Miehle-Dexter 3-Lobe Rotary Positive Blowers. The advantages of wide pressure and speed ranges, with capacities from 50 to 4000 cfm, make M-D blowers the most efficient for moving materials by air. There's a big difference when M-D blowers are used. May we demonstrate why?

The performance figures are convincing . . . write today!

Miehle Dexter



Miehle-Dexter Supercharger Division of The Christensen Machine Company, Racine, Wisconsin • Another Product of Miehle-Goss-Dexter, Incorporated

Eastman

First to be specified by America's leading OEM's

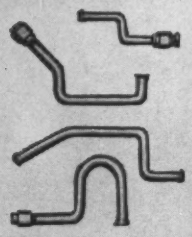
It's a known fact that many leading Original Equipment Manufacturers submit their original specifications for their *first* quotation to Eastman.

EASTMAN's unequalled experience in hydraulic conversion, plus many original designs shown in a few popular Eastman fittings at the right—give your product an appearance of quality that improves its competitive position in your field. It's a mark of distinction to be Eastman equipped!

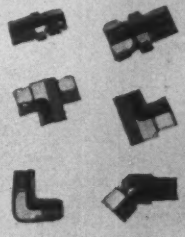
EASTMAN Engineering Service . . . Backed by Unequalled Experience

It is also a known fact that Eastman's co-operative engineering counsel and service is highly respected and often requested by leading OEM's. Let Eastman engineers help you lay out your fluid power lines—from pump to point of work—effecting economies in design, improving performance and increasing user satisfaction.

Let EASTMAN recommend the *best assembly . . . for the best performance . . . at the lowest cost.*

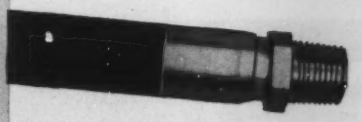


Bent Tubing with the necessary fittings to meet your own specific requirements.

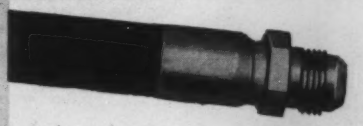


Adapters, Adapter Unions and Boss "O" Ring Fittings. All types and sizes available.

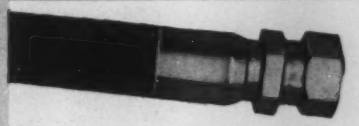
A COMPLETE LINE OF HYDRAULIC FITTINGS and HOSE ASSEMBLIES . . .



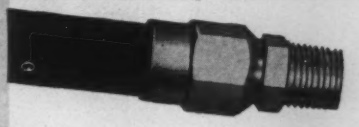
Permanently Attached Male (NPTF) for 1, 2 and 3 wire braid rubber cover hose, and 4 spiral wire extra high pressure hose.
Sizes: 3/16" thru 3".
Wkg. pressure: 375—5000 p.s.i.



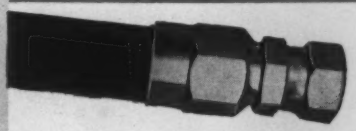
Permanently Attached Male Flare (JIC) for 1, 2 and 3 wire braid rubber cover hose.
Sizes: 3/16" thru 2".
Wkg. pressure: 375—5000 p.s.i.



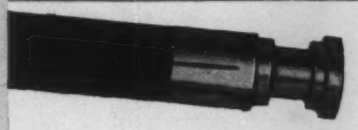
Permanently Attached Swivel Female for 1, 2 and 3 wire braid rubber cover hose.
Sizes: 3/16" thru 2".
Wkg. pressure: 375—5000 p.s.i.



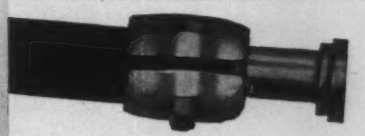
Reusable Male (NPTF) for rubber and cotton cover hose.
Sizes: 3/16" thru 1 13/16".
Wkg. pressure: 375—5000 p.s.i.



Reusable Swivel Female for rubber and cotton cover hose.
Sizes: 3/16" thru 1 13/16".
Wkg. pressure: 375—5000 p.s.i.



Permanently Attached Flanged Head Couplings for 1 and 2 wire braid rubber cover hose.
Sizes: 1/4" thru 2".
Wkg. pressure: 375—5000 p.s.i.



Clamp Type Coupling with split flange stems for 1 and 2 wire braid rubber cover hose.
Sizes: 1/4" thru 2".
Wkg. pressure: 375—5000 p.s.i.

Power Steering Assemblies to meet all your requirements.

Eastman *first in the field*

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ENGINEERS:
Write for Technical Bulletin 200 for Complete Information and Data on Fluid Power Lines.

Circle 468 on Page 19

compact . . . power-packed

New General Electric

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IMMEDIATE SHIPMENT of popular Tri-Clad '55' motor ratings—through 125-hp—is provided from factory, district warehouses, and distributor stocks.

TRI 55 CLAD REG. U.S. PAT. OFF. **motors can help you . . .**

DELIVERY CYCLE

NOW AVAILABLE THROUGH 125-HP

CONVENIENT WAREHOUSE STOCKS provide immediate shipment of any popular G-E Tri-Clad '55' motor rating up through 125-hp. Nationwide stocks are maintained by distributors as well as 34 G-E district warehouses.

HIGH-SPEED PRODUCTION of all types of motors is provided by new automated manufacturing facilities. With these facilities, special-purpose motors are produced by General Electric almost as fast as standards.

G-E PRE-ENGINEERING SERVICE provides special motor designs to meet your immediate or future needs. Where conditions warrant, such motor designs could be stocked at nearby G-E warehouses to provide fast delivery.

immediate shipment . . . popular NEMA ratings

How many additional sales could your company have made this year if you could have delivered your product faster?

In today's highly competitive market, often just a few days can make the difference between a lost sale, and an important order for your factory.

NOW, TO HELP YOU REDUCE THE DELIVERY CYCLE OF YOUR PRODUCT, General Electric offers immediate shipment of popular Tri-Clad '55' motor ratings—up through 125-hp—from nearby warehouse stocks. Or, if you use a motor that is not standard, G.E. can give you faster shipment from the world's most modern motor manufacturing plant.

IF MOTOR DELIVERY TIME IS A FACTOR in your production scheduling, you can now reduce your delivery cycles, make shipment promises with more assurance, and give improved customer service.

FOR MORE INFORMATION on the complete Tri-Clad '55' motor line—now available through 125-hp, contact your nearby G-E Apparatus Sales Office or Authorized Distributor.

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GENERAL ELECTRIC COMPANY
Schenectady 5, New York

Please send me the following publications:

☐ **FREE BULLETIN (GEA-6602) describes advanced features of new Tri-Clad '55' motors through 125-hp.**

☐ **FREE SLIDE RULE (GEN-148) to determine weight and space-saving benefits of new Tri-Clad '55' motors.**

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Progress Is Our Most Important Product

Circle 469 on Page 19

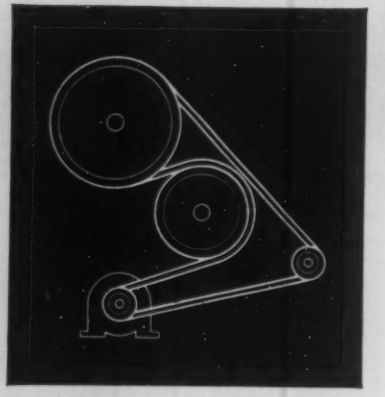
GENERAL ELECTRIC

V-Belt Designer's Notebook

A special V-Belt Engineering Service to help you cope with 7 Drive Problems created by space-saving modern design

A checklist of V-belt drive designs which require specialized engineering. With a description of the compensating characteristics which can be built into special Dayton V-Belts. Sources: Case histories from the files of the Dayton Special V-Belt Engineering Service and "The Dayton Handbook of V-Belt Drive Design and Selection."

Here's a typical example of efficient, compact, modern design—an automatic washer with a Dayton V-Belt Drive.

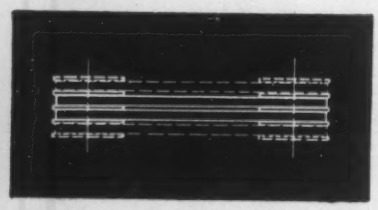


Note that it imposes three design requirements, (1) a torturous back bend (2) sub-diameter pulleys (3) a limited tension take-up area. Yet the design is efficient because Dayton V-Belt engineers developed a belt especially adapted to these three punishing conditions.

You'll find similar examples in machine tools, agricultural machinery and wherever drive space is limited. You've seen them yourself—the designs which dictate sheave misalignment, back-side idlers, underbelting; plus others which use V-Belts as a clutch and which impose excessive shock loads on the belt.

HERE ARE THE MAJOR CONDITIONS WHICH AFFECT V-BELT PERFORMANCE

Underbelting

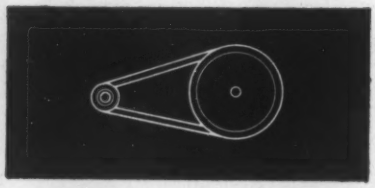


Underbelting is found where space is limited or as a result of very low belt speeds. It will cause belts to slip, run hot and wear out very quickly. A temporary cure, commonly employed, is to over-tension the belt – thus throwing excessive loads on the bearings.

The design requires a high capacity belt with extra-strength cords found in Dayton's Super-Thorobred series or, in difficult cases, belts with both a high coefficient of friction and extra strength like the raw-edge Dayton Cog-Belt.*

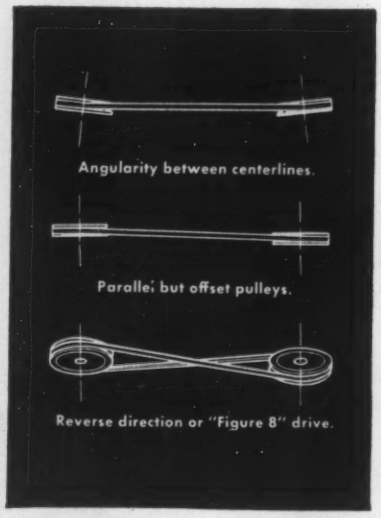
Sub-diameter sheaves

Belts driven by sub-diameter sheaves are inclined to succumb to accelerated flex failure. Tensioning problems are a usual result.



Sub-diameter sheaves require extremely flexible belts for satisfactory service. The required flexibility may be obtained by using thin V-Belts—where drive capacity is not high. When considerable capacity is required, Dayton Cog-Belts will give the most satisfactory performance. Their exclusive design permits exceptional flexibility. Die-cut raw edges provide high coefficient of friction, transmit maximum power from sub-diameter sheave arcs.

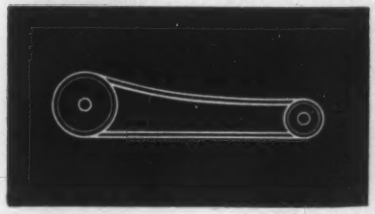
Misalignment



Misalignment causes uneven tension across the face of the belt—producing abnormal belt and pulley wear and uneven bearing loads.

A suitable approach is to use highly extensible cords of the latest synthetic fibers in the strength band of the V-belt. Dayton's Development Engineer can prescribe the material best suited to your needs.

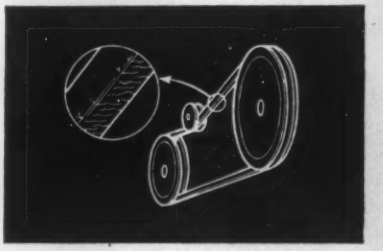
Fixed centers



Proper tension cannot be maintained with fixed centers or where center distance adjustment is inadequate. Without proper tension, belts slip and need frequent replacement.

Dayton V-Belts with low-stretch neutral-axis cords are best suited for applications with little or no provision for center distance adjustment. Still higher performance is gained if the belts have maximum cross-sectional stability which helps keep the belt from seating in the sheave groove.

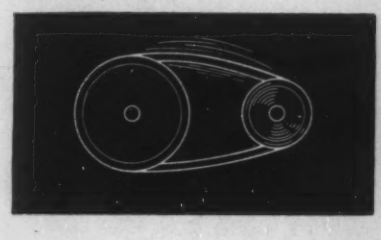
Back-side idlers



Cracks will appear on the under side of the belt, since back-side idlers force the belt to flex in a direction contrary to its construction. Use of spring-loaded back-side idlers may result in belt-snapping.

Where back-side idlers are used to provide tension take-up, they must never be smaller than the smallest pulley in the drive. Dayton V-Belts used in this case employ tension or stretchy type materials in the compression section and have a relocated neutral axis.

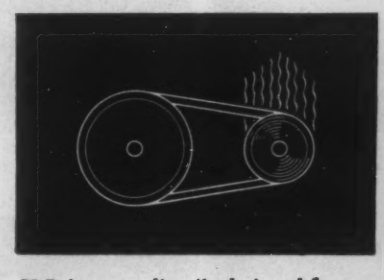
Excessive shock



Excessive shock can cause the belt to snap as well as promote bearing troubles and sheave misalignment.

Belts subject to excessive shock or heavy pulsation require strength band constructions which offer changeable ratios between stress and strain without taking a permanent stretch. Belts with soft cross sections — that will ride up and down in the groove — work well under shock as do wide angle belts. Any of these belts are available from Dayton.

Using as a clutch



V-Belts are ordinarily designed for constant loads and will burn when used as a clutch.

But, belts especially designed for use as a clutch will readily slip when a load is suddenly applied or released. Dayton cover stocks used here have a low coefficient of friction and high resistance to wear.

DAYTON'S SPECIAL V-BELT ENGINEERING SERVICE

Make use of Dayton's Special V-Belt Engineering Service when you encounter any of these designs. Your Dayton V-Belt design engineer is an expert who has devoted himself exclusively to V-Belt Drives. Your design may permit a minor modification which would adapt it to the use of low-cost standard V-Belts. Other standard Dayton V-Belts available for special applications are the Double-Angle V-Belt, the Double Cog-Belt, the Variable Speed Cog-Belt and the back-side idler V-Belt.

With one of the finest research and development laboratories in the industry, Dayton research engineers constantly advance V-Belt knowledge. They develop basic theory, prove the characteristics of the newest compositions and materials available to the rubber industry and test the performance of theoretical constructions. All of this acquired information is at your call when you need a special V-Belt.

Now, while your design is on the drawing board, is the time to call your Dayton V-Belt design engineer. He'll help you select the V-Belt which is tailored to your specific drive. The result — a compact, versatile design which meets all your minimum design requirements and one that will give its users years of trouble-free service.

Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis.

*T. M. © D. R. 1957

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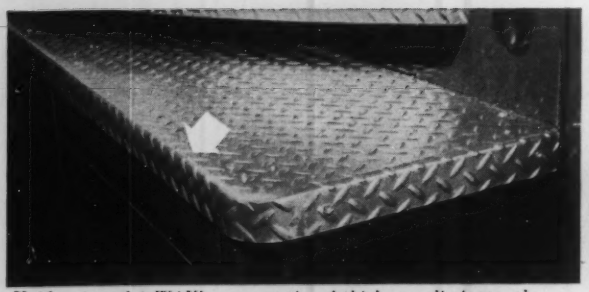
WORLD'S LARGEST MANUFACTURER OF V-BELTS

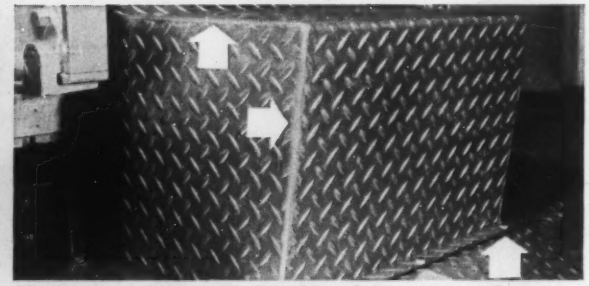
If you haven't received your copy of Dayton's authoritative Handbook of V-Belt Drive Design and Selection, write for it now. Just give us your name, title, and the address of your firm.

tough fabricating job on fire engine proves 4-WAY'S® versatility

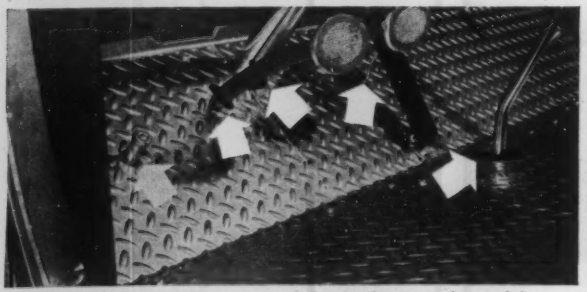
Fabrication to form even the varied and complex shapes used on firefighting equipment is no problem with 4-WAY Safety Plate. No special tooling is necessary. Ordinary cutting, drilling, forming and similar standard shop equipment is all that's needed. Good reason why this leading chassis and body manufacturer has specified Inland 4-WAY for more than 15 years! 4-WAY is used in an uncommonly wide variety of ordinary and extraordinary applications. For complete information and specifications, write Dick Prendergast, Room 1262 at the address below.



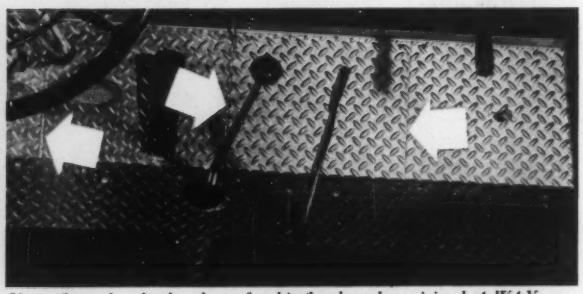
Uniformity of 4-WAY's cross-sectional thickness eliminates the possibility of deflection while bending, even at sharpest angles. Standard equipment can be used.



Whether the application calls for welding, bolting, or screw fastening, all are easily accomplished on 4-WAY with conventional methods.



Punching, drilling or flame cutting holes for fasteners, foot pedals, etc. is no problem with 4-WAY.



Notice how cleanly the plates for this floorboard are joined. 4-WAY can be sheared to extremely close tolerances eliminating all guesswork and make-overs.

Inland 4-WAY® Safety Plate

Carried in stock by all leading steel distributors

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Sales Offices: Chicago • Milwaukee • St. Paul • Davenport
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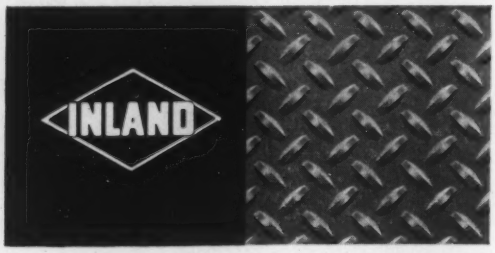


Circle 471 on Page 19

Prongs snap into punched or drilled hole

CUSTOM-DESIGNED AND MASS PRODUCED TO YOUR PARTICULAR REQUIREMENTS

Dot plug buttons were originally used in automobiles to fill spaces on standard models which, on de luxe models would be occupied by such extras as cigarette lighters, radio controls and so on. They are now also widely used as lenses for indicator lights and as identification buttons on instrument and control panels of all kinds.

Available in clear or colored plastics... brass or steel in all standard finishes... embossed and enamel-filled or molded to show company insignia or other identification symbols . . . Dot plug buttons snap into place and stay where they're put even under conditions of extreme vibration. Yet they can be removed and replaced repeatedly without damage.

CARR FASTENER COMPANY

DIVISION OF UNITED-CARR FASTENER CORPORATION 31 Ames Street, Cambridge 42, Massachusetts

MAKERS OF DOT FASTENERS

Circle 472 on Page 19

PRECISION DYNA-SEAL

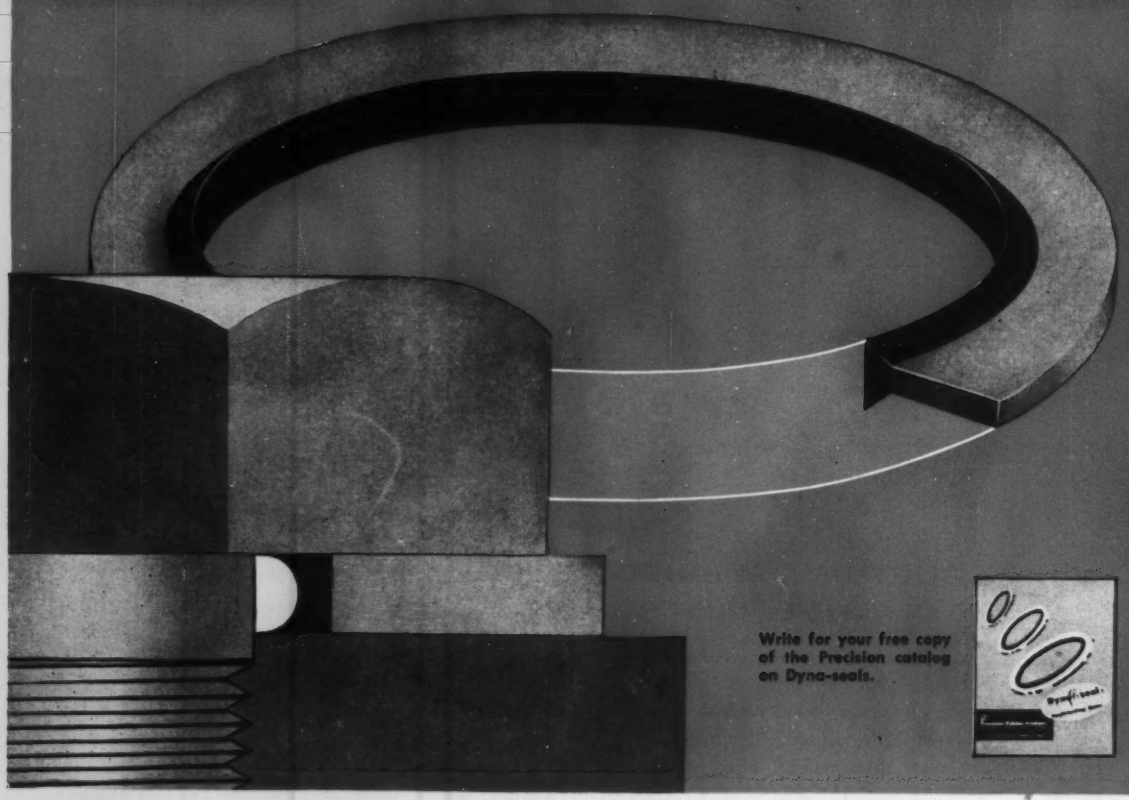
For face to face sealing

Easy-to-handle one piece seal of rubber bonded to a steel washer.

Available in-stock sizes for No. 5 screw to 1-¼" bolt.

No special machining required.
Reduces assembly costs.
Positive sealing up to 10,000 P. S. I.
Vibration proof, lock washer action.
Reduces bolting torque.
Reusable - cuts maintenance.

Let a Precision engineer demonstrate the Dyna-seal cost and labor saving advantages to you.



Write for your free copy of the Precision catalog on Dyna-seals.

Precision Rubber Products Corporation

"O" Ring and Dyna-seal Specialists

Box 431, Oakridge Drive, Dayton 7, Ohio **Canadian plant at: Ste. Thèrése de Blainville, Québec**

Always, at SKF, you will receive unbiased advice

because

– All four basic types of anti-friction bearings are available from **SKF**.

because

– They offer an extraordinarily wide range of sizes and combinations to meet virtually any requirement.

because

– Their long experience in the widest variety of bearing applications is your assurance of receiving sound recommendations.

because

– Thousands of manufacturers have been using the **SKF** Bearing Advisory Service for many years – always with good results. This dependable service is available to you, too. 7754

SKF®

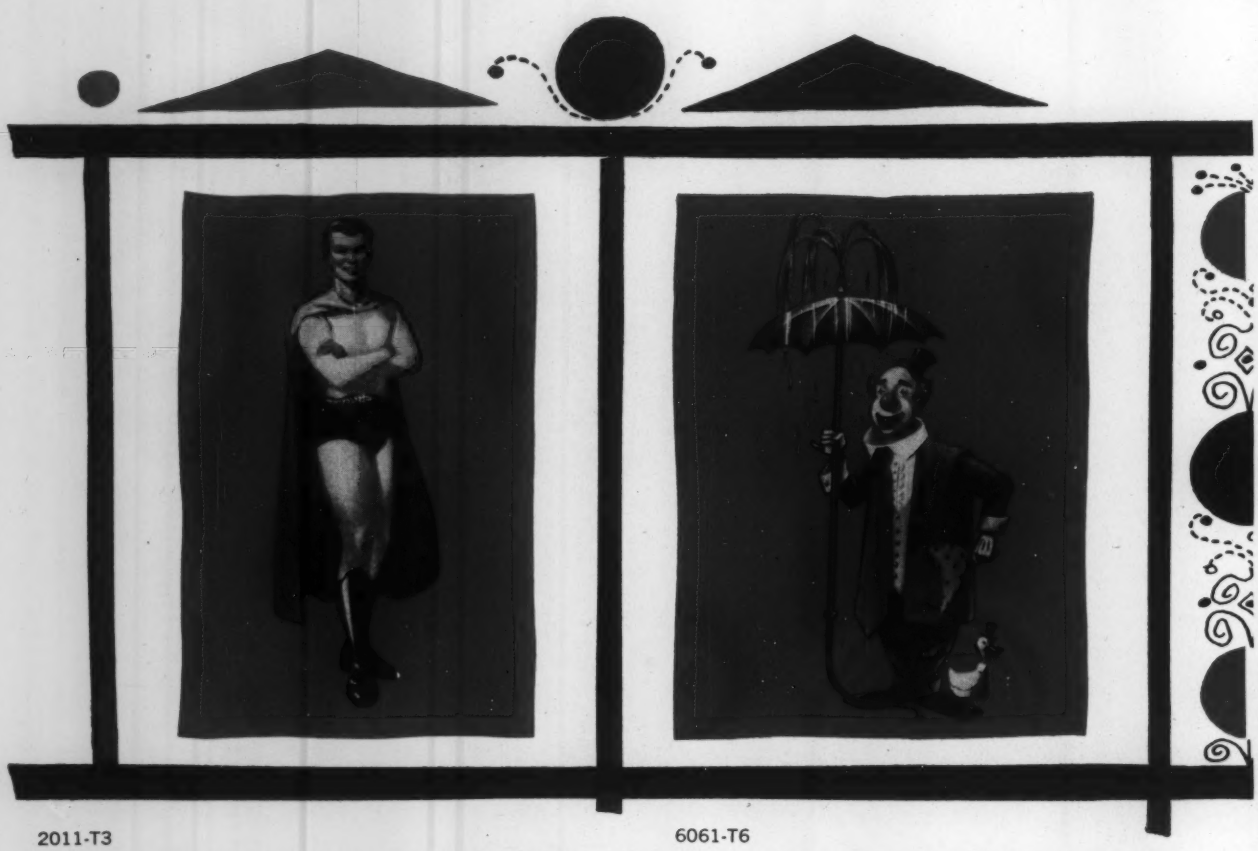
EVERY TYPE—EVERY USE

- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings* ("Tyson")

® Reg. U.S. Pat. Off.

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

ALCOA'S NEW COLOR MOVIE



2011-T3

Here's the "Lightweight Champion of the Machining World." Watch this free-machining aluminum alloy perform amazing feats of economy and versatility through a blizzard of fine, crisp chips. It's just the ticket for most screw machine products.

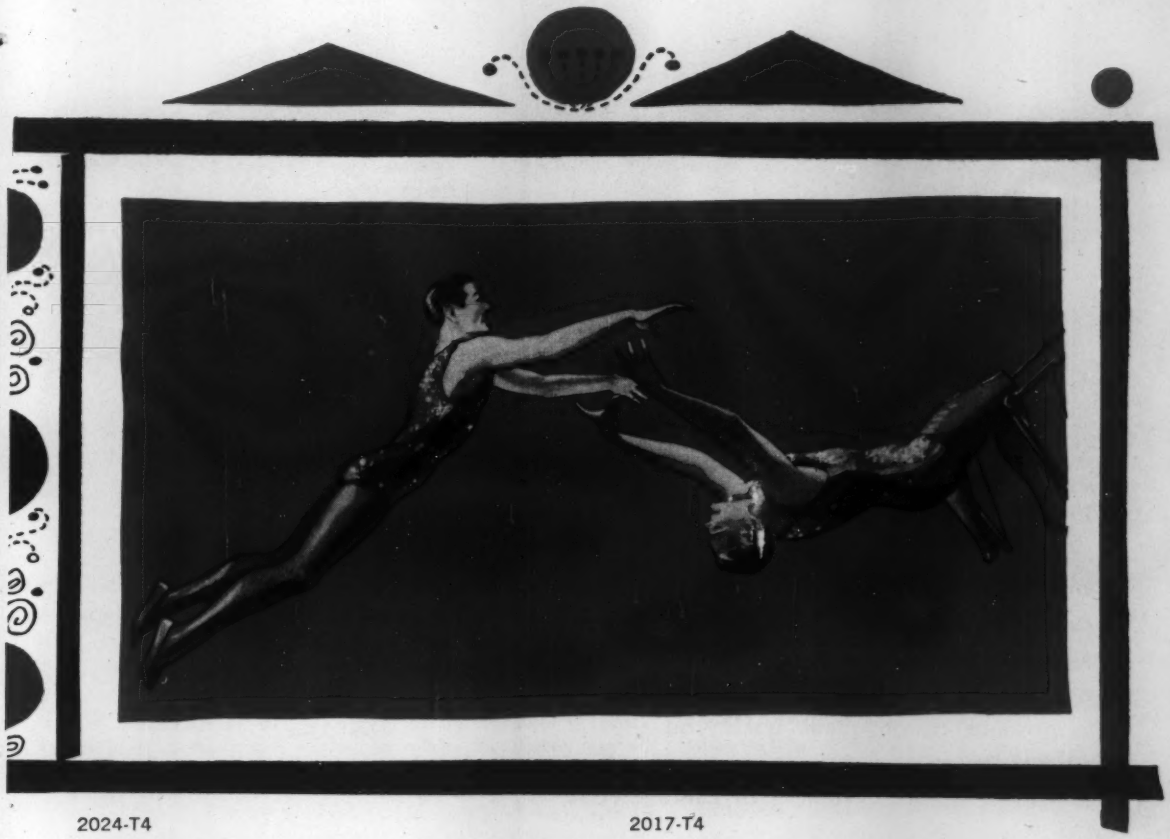
6061-T6

The fabulous alloy that's unequaled where service calls for exceptional resistance to corrosion, suitability for welding or brazing. It's the most finishable of the aluminum screw machine stock alloys.

FREE SHOWING

Be sure to see these amazing alloys perform their spectacular feats of strength, economy, machinability, finishability and corrosion resistance. Determine a date for a showing to your group and contact your nearest Alcoa sales office. They'll confirm a show date for you and send the film to reach you in time for your meeting. No charge. Aluminum Company of America, 873-M Alcoa Building, Pittsburgh 19, Pennsylvania.

"THE FOUR AMAZING ALLOYS" DEMONSTRATES THE VERSATILITY OF ALCOA ALUMINUM SCREW MACHINE STOCK



2024-T4

The daring "Aircraft Alloy." Noted for its strength. Tops where tight, vibration-, strain- and wear-proof assemblies are a must.

2017-T4

The startling alloy that's priced lowest of the aluminum screw machine stock alloys. Handles tough service jobs with a high degree of machinability.

Your Guide to the Best in Aluminum Value

ALCOA ALUMINUM
SCREW MACHINE STOCK
ALUMINUM COMPANY OF AMERICA

NEW! "ALCOA THEATRE"
EXCITING ADVENTURE
ALTERNATE MONDAY EVENINGS

Learn why leading companies have switched to Alcoa Aluminum Screw Machine Stock

ALUMINUM COMPANY OF AMERICA
873-M ALCOA BUILDING, PITTSBURGH 19, PENNSYLVANIA

Please send booklet with direct quotes from industry leaders on why they buy from Alcoa.

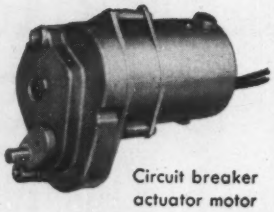
NAME ..... TITLE .....

COMPANY .....

ADDRESS ..... CITY ..... STATE .....

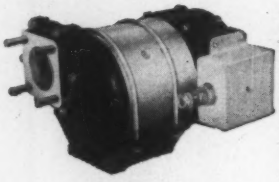
Circle 475 on Page 19

Impact concrete drill motor

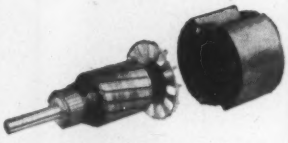


Circuit breaker actuator motor

Precision-built instrument motor



Hydraulic pump motor



Motor parts for portable electric tools

Prescription POWER...

For Top Performance of Your Product

"Prescription Power" with a Lamb Electric Motor means–

- . . . a motor designed to the *exact requirements* of your product . . .
- . . . *built-in dependability* that results from 42 years of small-motor experience . . .
- . . . *favorable cost* because our plant is geared to produce custom-made quality on a volume basis.

May we demonstrate these advantages of Lamb Electric Motors to *you?*

THE LAMB ELECTRIC COMPANY • KENT, OHIO

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

If you are interested in any of the above motors, write and we shall be glad to send full information.

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Circle 476 on Page 19

NOTHING *can equal Stainless Steel*

in its unique combination of properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. For a reliable source of supply, United States Steel offers you the widest range of types, finishes and sizes.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
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USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS
PIPE • TUBES • WIRE • SPECIAL SECTIONS

USS

UNITED STATES STEEL

FOR HIGH TEMPERATURE STRENGTH. The Ryan Firebee is a pilotless jet airplane that flys about 600 mph at altitudes up to 40,000 feet. All three armed services are using it for target practice—to simulate attacking aircraft. Fuselage and turbojet engines use substantial quantities of Stainless Steel—mostly because of its excellent strength/density ratio at elevated temperatures.

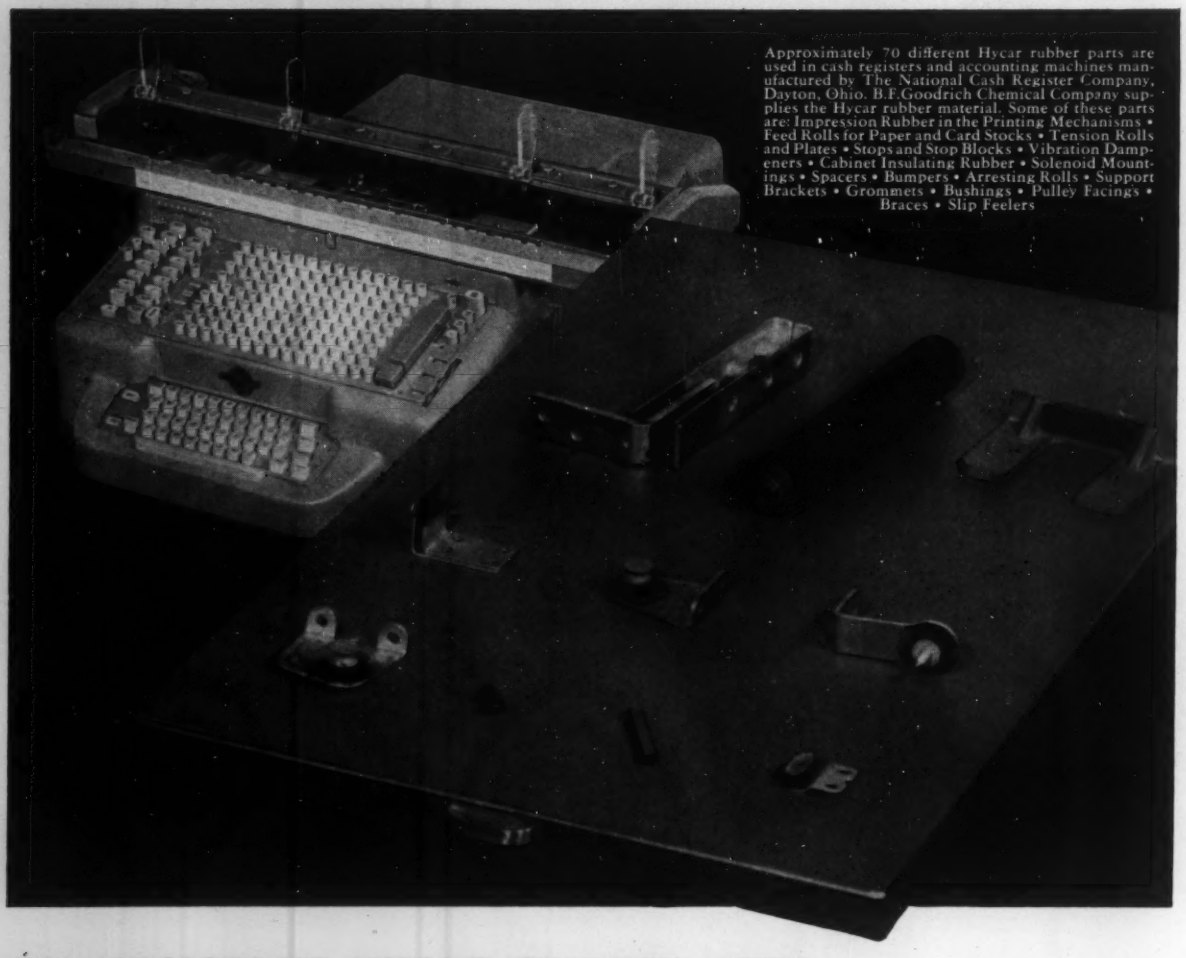
FOR CORROSION RESISTANCE. If you're a photographer, you know that hypo is awfully corrosive. This print washer (it holds 75 8x10 prints in one loading) is made completely from Stainless Steel by the Arkay Corporation, in Milwaukee. For proof that Stainless is easy to fabricate, notice that the drum has 1,700 perforations, and double lockseam soldered joints are used throughout.

FOR TAKING A BEATING. These supermarket check-out counters are made from USS Stainless Steel. They withstand the pounding of heavy containers and are unaffected by corrosive meat and produce juices. It only takes 20 minutes for one girl to clean all eleven counters shown here. The Robert Becht Company of Cincinnati made them.

Circle 477 on Page 19

News about

B.F.Goodrich Chemical *raw materials*



Approximately 70 different Hycar rubber parts are used in cash registers and accounting machines manufactured by The National Cash Register Company, Dayton, Ohio. B.F.Goodrich Chemical Company supplies the Hycar rubber material. Some of these parts are: Impression Rubber in the Printing Mechanisms • Feed Rolls for Paper and Card Stocks • Tension Rolls and Plates • Stops and Stop Blocks • Vibration Dampeners • Cabinet Insulating Rubber • Solenoid Mountings • Spacers • Bumpers • Arresting Rolls • Support Brackets • Grommets • Bushings • Pulley Facings • Braces • Slip Feelers

OIL RESISTANT HYCAR RUBBER CUTS BUSINESS MACHINE MAINTENANCE

TO absorb shock, support weight, deaden sound, supply driving power, dampen vibration . . . these are some of the jobs being done in business machines by parts of Hycar nitrile rubber.

Hycar rubber is ideal for these parts because most of them have to resist oil which destroys ordinary rubbers. Equally important is Hycar's resistance to the attack of solvents and other fluids used for machine cleaning and maintenance.

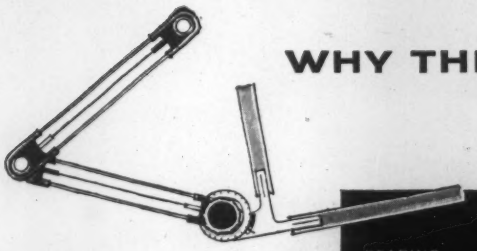
Versatile Hycar has many other unique properties for applications requiring: flexibility with high strength; superior aging; exceptional resistance to abrasion, oxidation, pressures, gas, temperature extremes and many chemicals.

Hycar nitrile rubber has made possible the development of many new products and the improvement of existing products. For information, write Department HK-6, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
Reg. U.S. Pat. Off.
American Rubber

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors



WHY THINGS RUN SMOOTHER WHEN YOU SPECIFY HYATTS

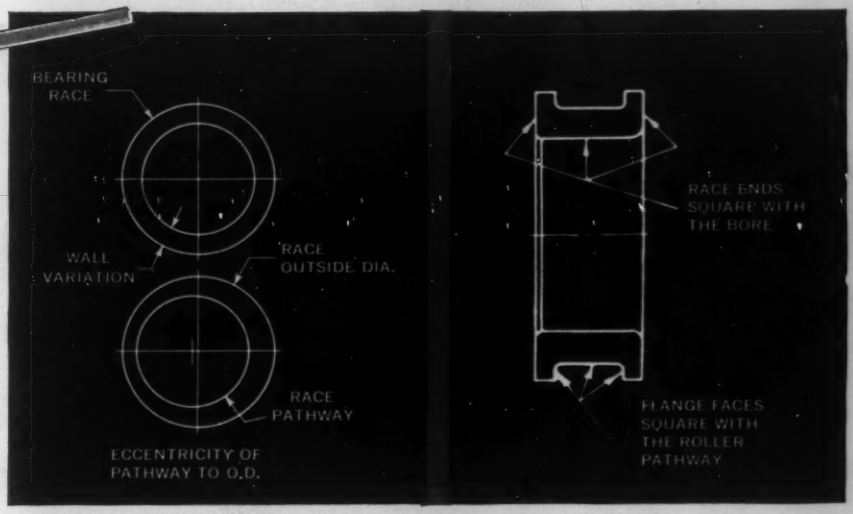


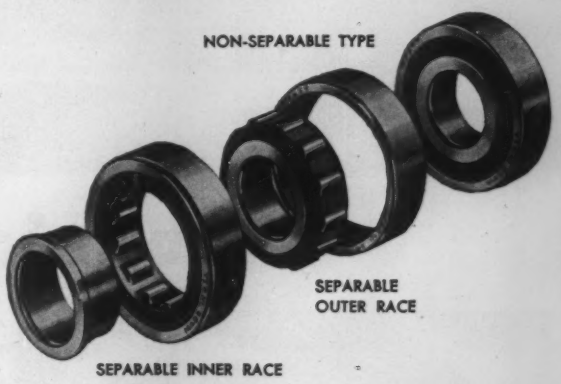
FIGURE 1 FIGURE 2

CLOSE CONTROL OF INTERNAL DIMENSIONS MEANS LONG, TROUBLE-FREE BEARING LIFE

The running accuracy and smoothness of a roller bearing is governed by the toleranees of its internal dimensions and clearance. Internal dimensions include concentricity of race diameters and squareness of all radial and axial surfaces, as briefly explained at right.

Because the internal dimensions of HYATT Hy-Roll bearings are so closely controlled, HYATTS run smoothly and quietly, last longer, and prevent equipment trouble due to excessive heat and vibration. You will find full selection and application data in HYATT Catalog 150, or call your nearest HYATT Sales Engineer. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.; Pittsburgh; Detroit; Chicago; and Oakland, California.

Concentricity of race diameters is usually defined in terms of wall variation (Figure 1) of the individual races, and radial run-out of the assembled bearing. Squareness of race and roller ends and flange faces is vital to prevent roller skewing with consequent heating and noisy operation. Figure 2 indicates the race surfaces which must be square with each other within minute tolerances depending on the grade of the bearing. The roller ends must also be square with the diameter for the same reason as above. End square tolerances are usually less than .001" for the most frequently used sizes.



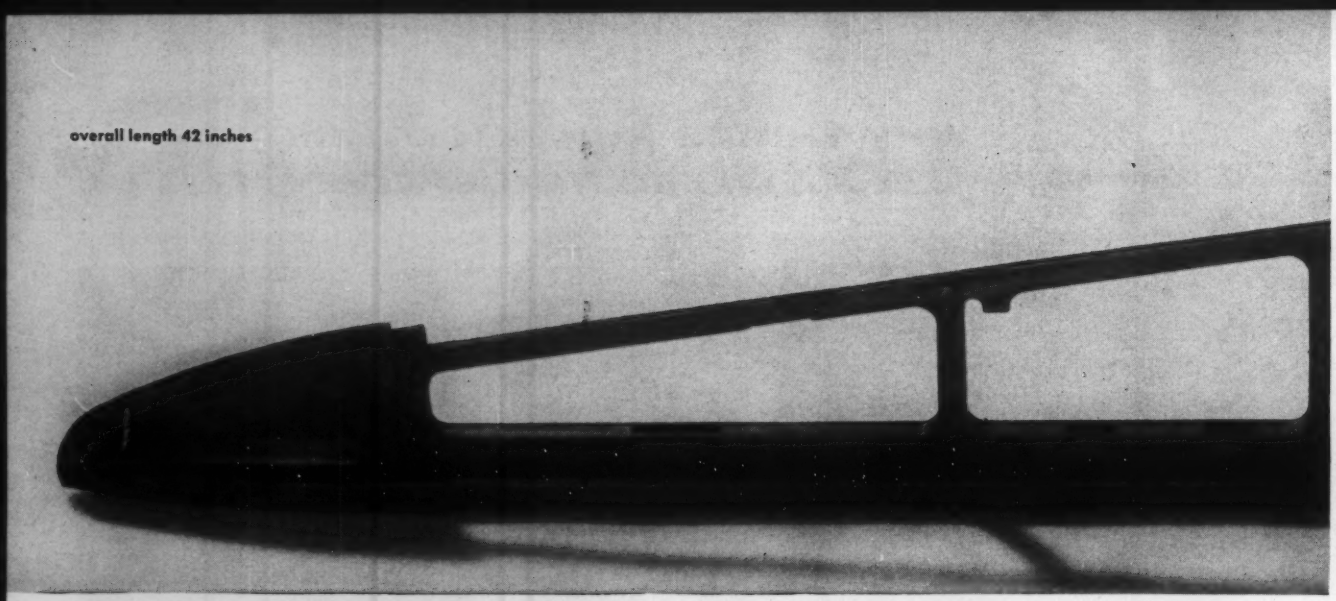
THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

1908–1958

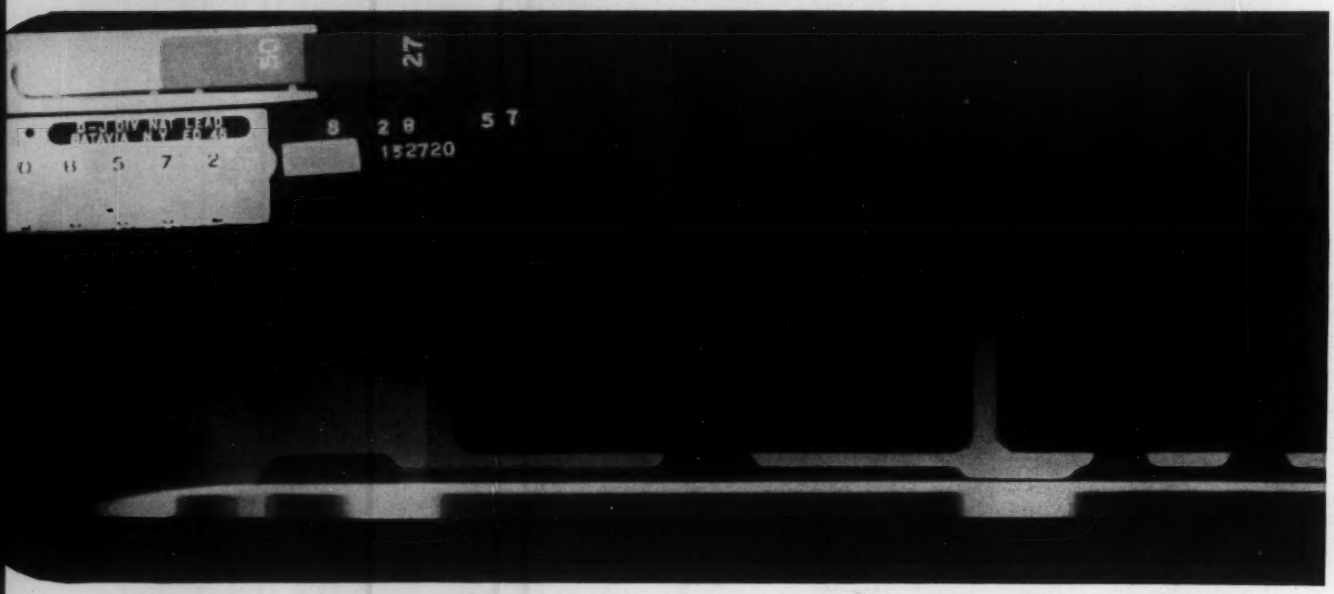
GM

FROM THE PIONEER OF THE PAST... THE PROMISE OF THE FUTURE

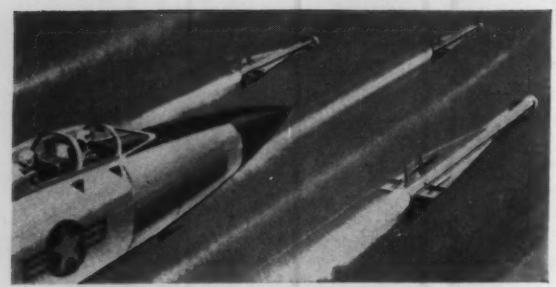
HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY



Now...from Doehler-Jarvis...die castings



X-ray of the Falcon's fin proves



The Falcon is an air-to-air missile built by Hughes Aircraft Company for the U. S. Air Force. Its light weight die cast stabilizer fins resist severe strain during course changes. It uses other Doehler-Jarvis die castings also.

Now *you* can have structurals die cast to standards as high as those for primary aircraft structurals*.

Die cast! With all the economy, precision, surface superiority, ease of assembly that implies. Die cast of aluminum, or of a high-purity magnesium alloy, like the 42" Falcon stabilizer fin.

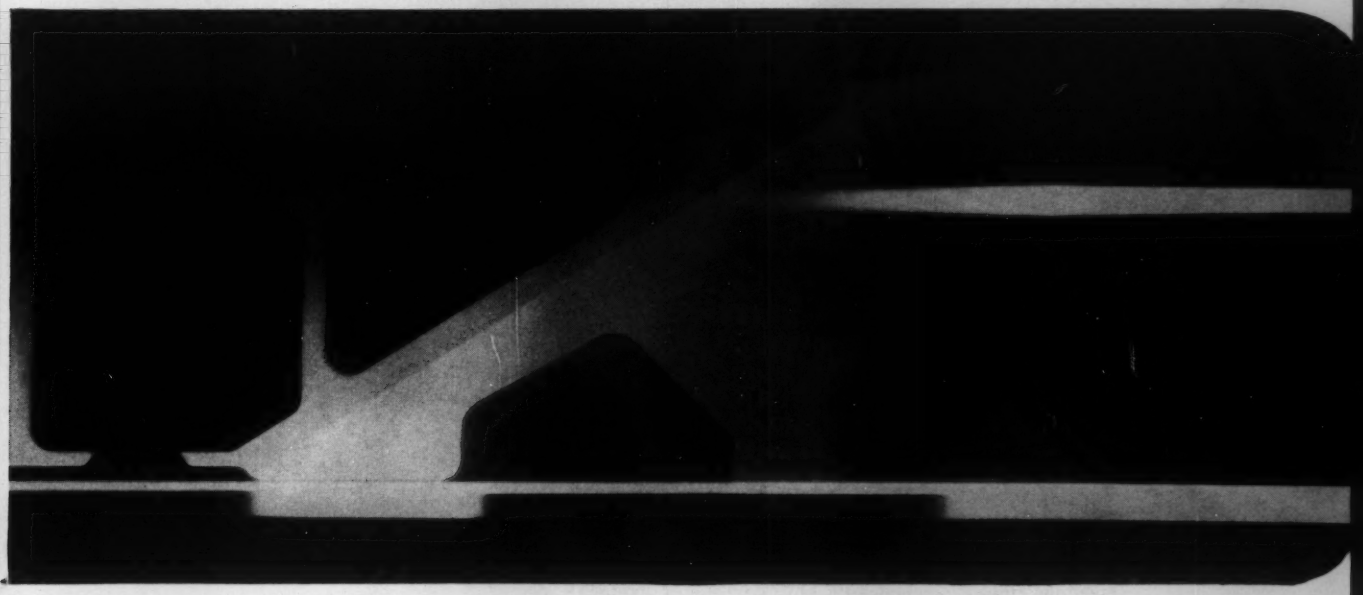
They said it couldn't be done!

But there you see such a structural! Along with X-ray proof of soundness, uniformity, primary-aircraft-structural* quality.

Mind you! The Falcon fin is in commercial production. Doehler-Jarvis has die cast thousands. Each has had to pass 73 inspections before acceptance . . . including 100% X-ray.

In *one* control, sections of castings are continuously tested for tensile strength. In this examination of physical properties, the castings normally exceed tensile specifications by 15% or

# of primary-aircraft-structural* quality



their uniformity and soundness

more. Quality is so high there has never been a single test below specification.

How did this come about?

Like many developments in die casting, this one started with a customer's need . . . Hughes Aircraft's.

They, and the Armed Services, needed such castings. The parts *might* be made other ways. But at what cost! What sacrifice in weight — and materials! If it *could* be die cast, if there *were* a magnesium alloy able to stand supersonic air stresses . . .

It took a while. But, with close cooperation from engineers of both Doehler-Jarvis and Hughes, the way was found.

Now you can list die castings of primary-aircraft-structural* quality among D and J availabilities. Get them from any Doehler-Jarvis plant.

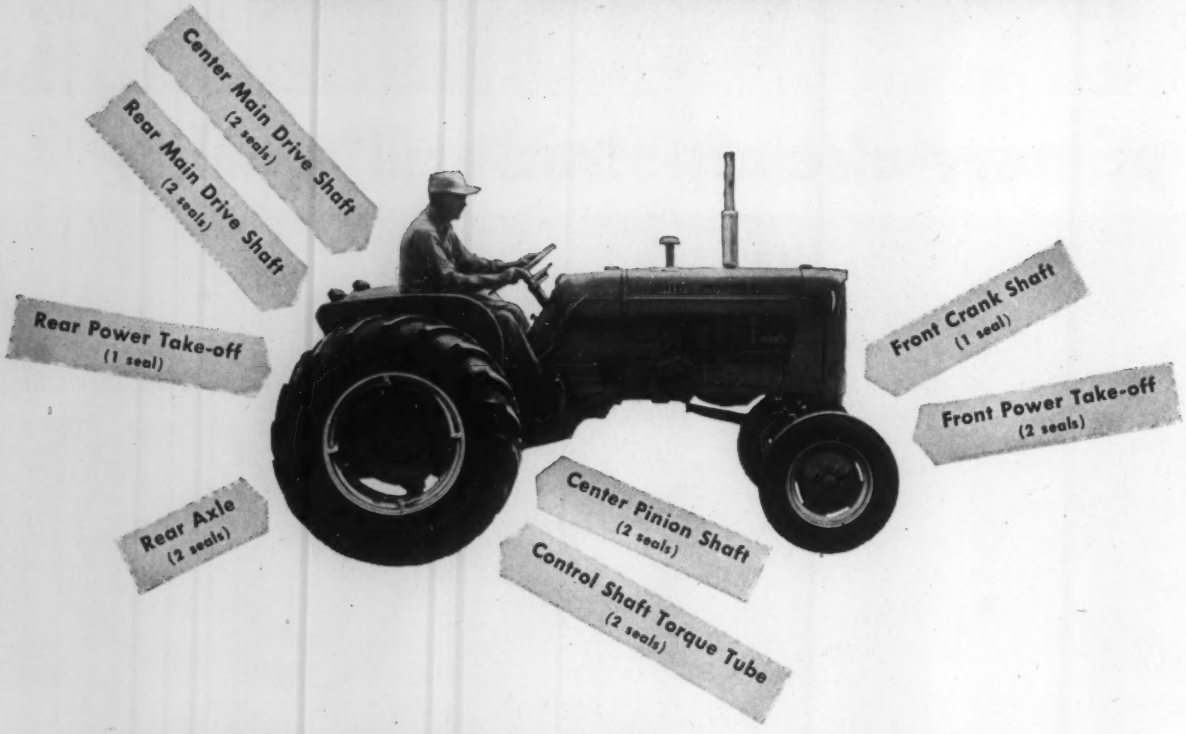
Circle 480 on Page 19

*A primary aircraft structural is a major load-bearing component member any single failure of which would result in loss of the aircraft.

Doehler-Jarvis
DIVISION OF NATIONAL LEAD COMPANY
General Offices: Toledo 1, Ohio

In Canada:
Barber Die Casting Co. Limited
Hamilton, Ontario

NEW! LOOK AT THE 14 POINTS WHERE ALLIS-CHALMERS D-14 TRACTOR RELIES ON NATIONAL SEALS



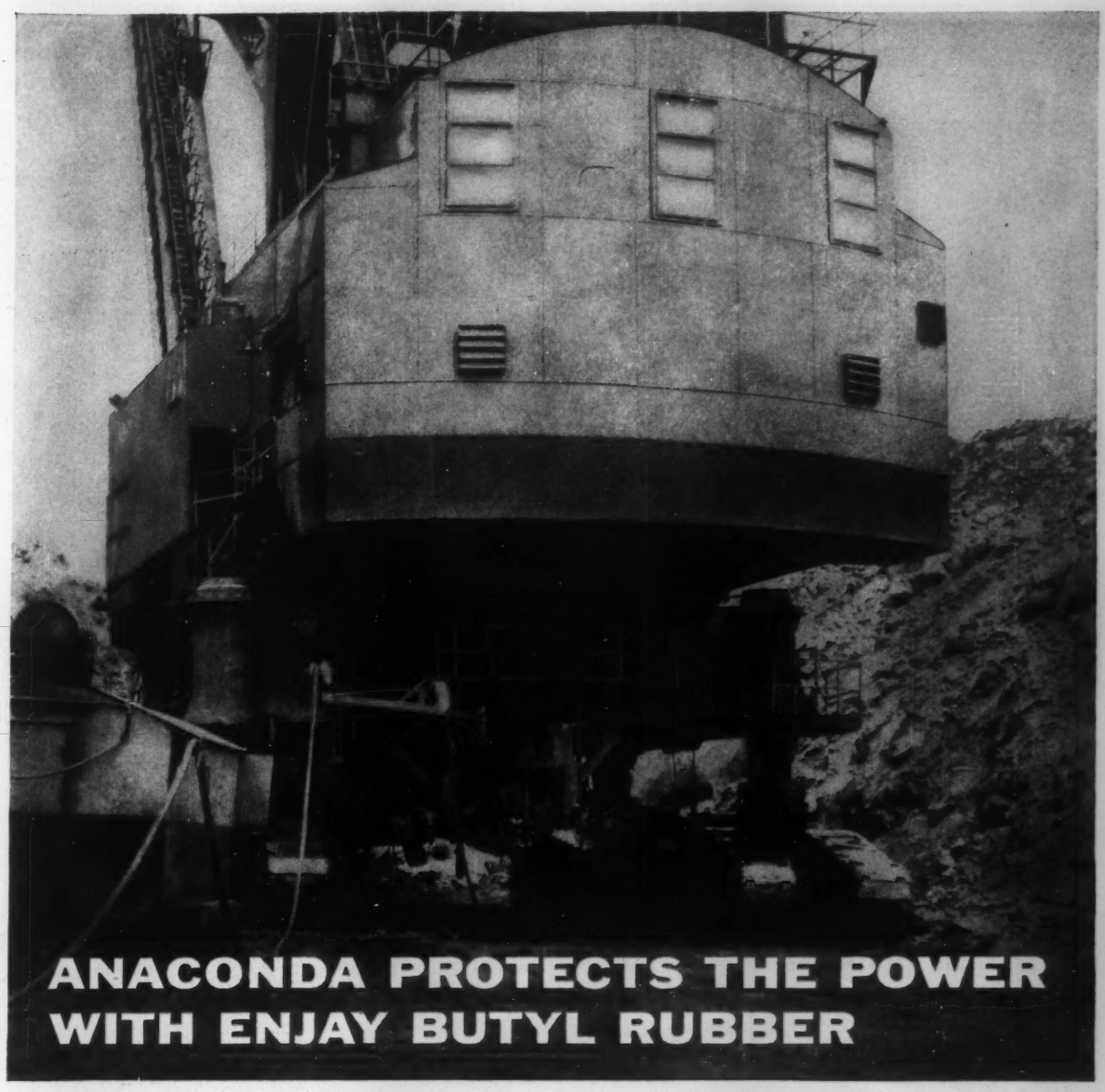
At 5 positions in the new D-14, Allis-Chalmers specifies steel-encased, spring-tensioned National leather oil seals. Two additional positions employ steel-encased, spring-tensioned Syntech® synthetic rubber seals. At still another position, the control shaft torque tube, a springless rubber-covered National Syntech is used.

All National seals in the D-14 (and many in Allis-Chalmers' equally new D-17 tractor) are standard design National seals. National supplies over 2,500 different types and sizes of oil seals, leather or synthetic. New seals are being designed daily to meet special applications.

For factual, professional engineering help on any shaft sealing problem, call your National Applications Engineer. He's listed in the Yellow Pages, under "Oil Seals—National Seal Division." He's backed up by 36 years of sealing experience, and the productive capacity of three modern plants.

NATIONAL SEAL Division, Federal-Mogul-Bower Bearings, Inc.

General Offices: Redwood City, California; Plants: Van Wert, Ohio, Downey and Redwood City, California 4589



ANACONDA PROTECTS THE POWER WITH ENJAY BUTYL RUBBER

Talk about impact resistance! The 5-year-old Anaconda cable supplying this giant shovel with power was buried under thousands of tons of rock when a whole wall of the open pit mine caved in . . . *yet the cable continued to supply power!* This is one of the many Anaconda products featuring Enjay Butyl for *outstanding* performance.

Enjay Butyl is *unmatched* in its resistance to impact and abrasion, moisture and weathering, ozone and corona . . . properties that make it the world's outstanding rubber value.

Low in cost and immediately available in a grade tailor-made for *your* electrical application, Enjay Butyl is *the* rubber to boost performance and cut costs. For further information, and for expert technical assistance, contact the Enjay Company.

ENJAY *Pioneer in Petrochemicals*

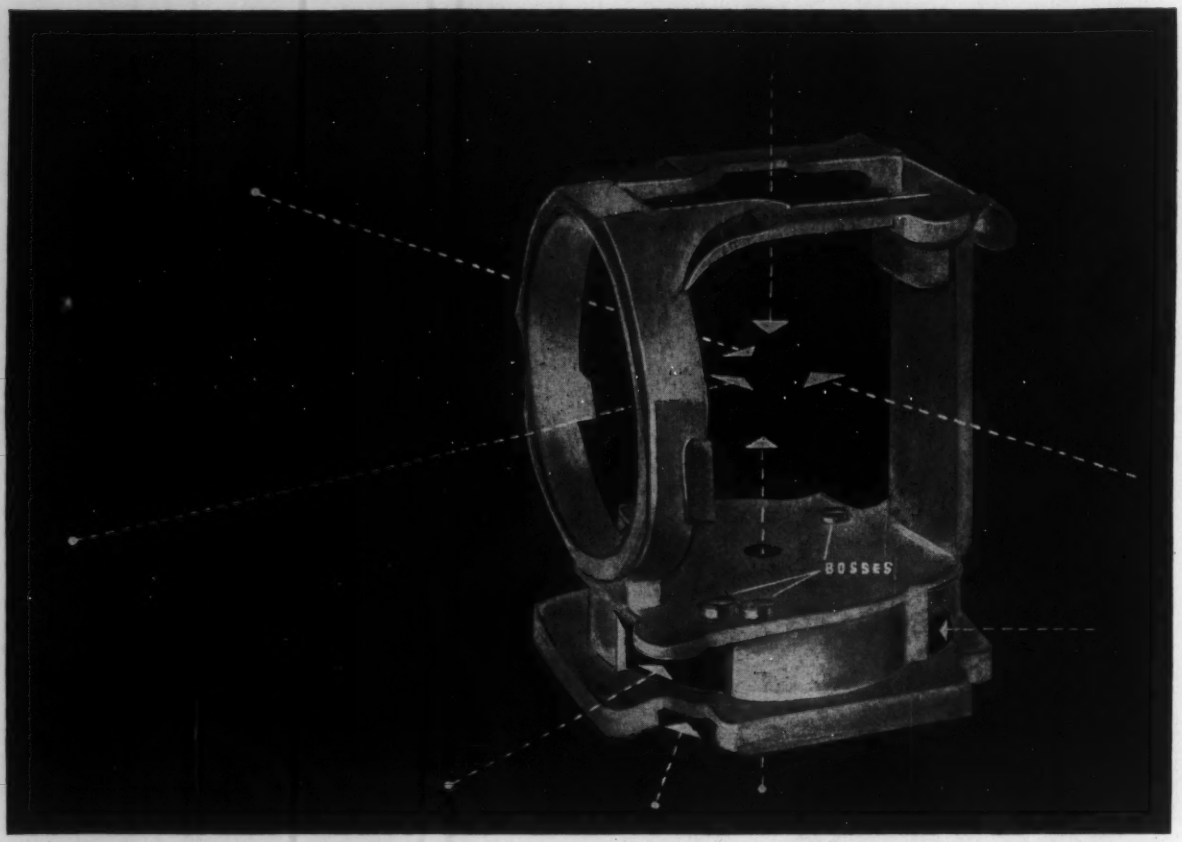
ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

ENJAY BUTYL

Enjay Butyl is the world's greatest rubber value . . . the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

Circle 482 on Page 19



Coring Too Intricate For Die Casting?

-----not at Parker

PARKER SALES ENGINEERS

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PHOENIX, Arizona
Fred B. Larsen • 6108 North 11 Avenue

ST. LOUIS 8, Mo.
Frank May • 4378 Lindell Boulevard

SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.

WILTON, Conn.
Girard L. Palmer • Belden Hill Road

WINTER PARK, Florida
Duane P. Davis • 110 South Orlando Avenue
Box 26

Because of intricate coring—together with internal bosses—sand casting seemed to be the only way to make this part. Necessary finish machining, however, boosted costs too high.

Then Parker die casting engineers tackled the job—and licked the coring problem. The result: a part with greater density, closer tolerances, better surface finish, no finish machining and—best of all—*much lower cost per unit.*

Here is just another example of the way Parker-engineered die castings save you money.

Parker has been a leader in die casting for over 50 years—an old hand with new ideas. This skill and experience can solve problems—and save money—on *your* component parts. Just call the nearest Parker sales engineer or send your prints to the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

high pressure ALUMINUM and ZINC die castings POWDERED METAL PARTS

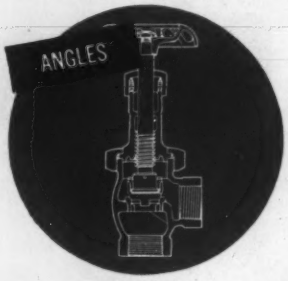
Circle 483 on Page 19

IF YOUR PRODUCT IS VALVE-EQUIPPED—
JENKINS VALVES WILL ADD AN

Extra Sales Feature

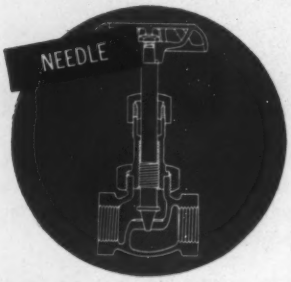
PACKAGE BOILERS • FIRE FIGHTING APPARATUS

LAUNDRY EQUIPMENT • DISH-WASHING MACHINES



STERILIZERS • PROCESSING EQUIPMENT UNITS

CLEANSING EQUIPMENT • HEATING UNITS



COFFEE URNS • PUMPS AND COMPRESSORS

Here's why—

You gain for your product the prestige of Jenkins Valves built by Jenkins continuous advertising in *Fortune, Business Week* and 25 other publications covering every valve-using industry.

You get the extra sales advantage of Jenkins famous Diamond and Signature trademark which identifies each valve.

—and here's how YOU SAVE TIME AND TROUBLE

You profit by Jenkins long experience in supplying valves for all types of products.

You add the valve know-how of Jenkins Engineers to your own designing skill. Modifications of standard valves, such as special handwheels, etc., can be provided when required. Send coupon today for information.

Give your product, and its purchasers, the *extra value* of Jenkins Valves . . . *it costs no more.* Jenkins Bros., 100 Park Ave., New York 17.

SOLD THROUGH
LEADING INDUSTRIAL DISTRIBUTORS

JENKINS VALVES
LOOK FOR THE DIAMOND MARK
SINCE 1864
TRADE JENKINS MARK
Jenkins Bros.

JENKINS BROS., 100 Park Ave., New York
Send Catalog No. 56
Name
Company
Address

Circle 484 on Page 19

HOW CAN YOU USE THIS NEW TYPE OF

ArmaSteel®

Tensile strength, 105,000 • Minimum yield, 85,000 • Minimum elongation in 2", 2% • Brinell hardness 269-302, (3.5-3.7 mm)
Machinability 20% better than steel of same hardness!

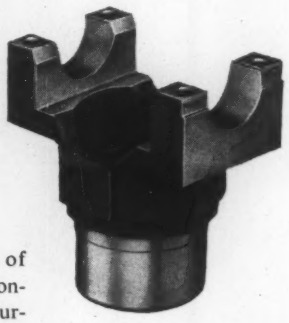
ARMASTEEL 88M has been developed to fill the automotive industry's needs for a material having increased wear resistance and high yield strength, yet at the same time retaining good machine characteristics.

ARMASTEEL 88M does not require heat treating and thus relieves customer facilities or eliminates capital expenditures. In many parts, distortion is a problem after heat treating. Parts made from ArmaSteel 88M can be machined without further heat treatment and still give good wear resistance.

This new castable metal is a pearlitic malleable iron which possesses substantially the same strength and the same wear characteristics as alloy steel forgings. Being a castable material, it has the two advantages of design flexibility and good machinability. Why 88M possesses these characteristics—and how it will fill the needs of American industry will be of interest to manufacturers and engineers in many fields . . .

PRODUCTION OF 88M—By accurately controlling the heat-treatment of ArmaSteel 88M in controlled atmosphere furnaces at 1750° for approximately 15 hours, all massive carbides are removed. This heat treatment is followed by a rapid air quench from high velocity fans. Tempering is controlled to provide a narrow range of hardness.

Universal Joint Yoke



Automatic Transmission Planet Gear Carrier

Surface hardening of ArmaSteel, if desired, does not require carburizing. Instead, flame-hardening, induction-hardening or simple immersion methods may be used. A surface hardness of 50 Rockwell C to 60 Rockwell C can be readily obtained. Wear-resistant properties in the hardened area are comparable and sometimes better than carburized steel, while the remaining sections retain their original toughness.

MACHINABILITY—In addition to performance characteristics, ArmaSteel offers good machinability. Carbon spots that are present in the Matrix of ArmaSteel allow the chips to break off readily, effectively reducing machining time and prolonging tool life. In comparative tests, ArmaSteel shows itself to be a more freely-machining material than steel bar stock or forgings of the same Brinell hardness.

Because of its ability to assume the shape of practically any molded cavity, 88M not only permits great

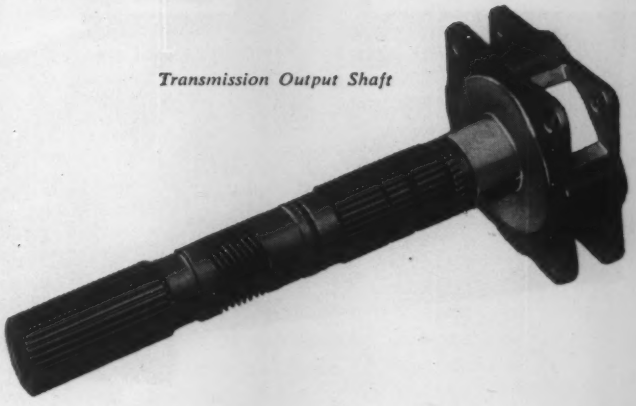
81

PEARLITIC MALLEABLE IRON?

88 M *developed by*

CENTRAL FOUNDRY DIVISION

Transmission Output Shaft

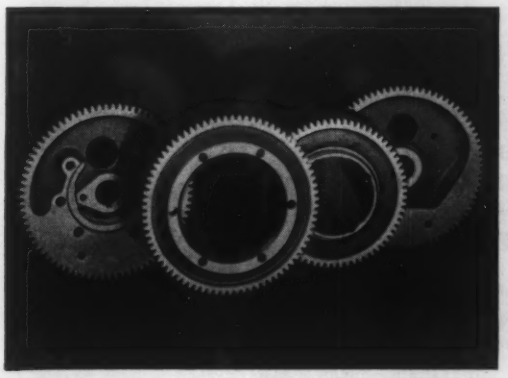


freedom in design but also possesses certain inherent physical characteristics not present in forgeable alloys.

APPLICATIONS—ArmaSteel 88M is now being cast for automatic transmission planet gear carriers and universal joint yokes for leading automobile manufactures. Other interesting applications now in the testing stage include transmission output shafts, and diesel engine idler, balance and crankshaft gears.

Just what hundreds of other applications are in store for 88M is still anyone's guess. But the more one examines its characteristics, the more it would seem that it will fill many needs in many types of products and industries. In your products, for example, you may well see where 88M could both improve performance of components subject to great wear or great stress, and at the same time reduce final cost because of the economy in casting and the economy in a material with superior machining characteristics.

Diesel Engine Idler, Balance and Crankshaft Gears



CASTING—Parts are cast in ArmaSteel 88M, here at Central Foundry Division, in either standard green-sand molds or the newer, more precise shell-molds. In addition to 88M, Central Foundry Division produces castings, on a volume basis, in grey iron, alloy grey iron, malleable iron, and ARMASTEEL 84M, 85M and 86M.

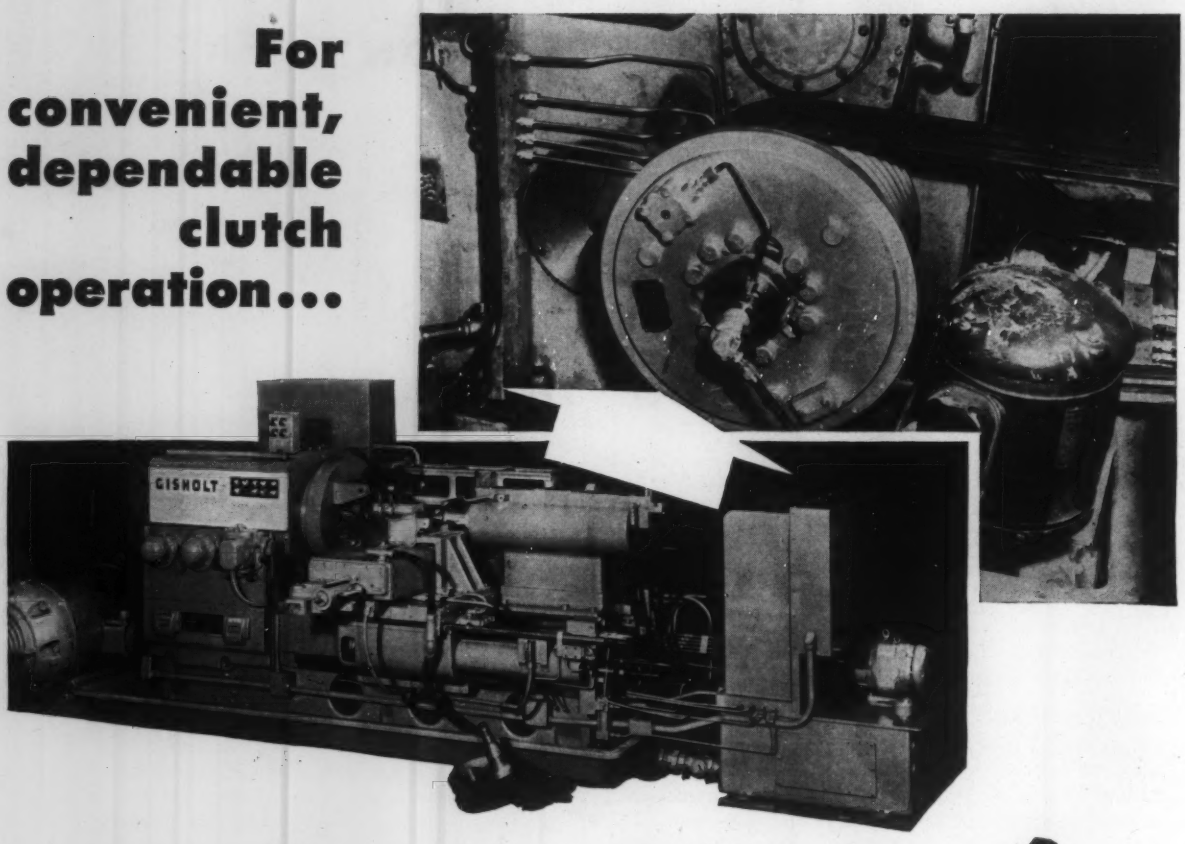
Our research facilities and engineering staff are prepared to help you determine whether 88M or any of the other materials now being cast at Central Foundry will fill your needs or help you reduce your over-all product cost.

Write for your copies of our two comprehensive manuals, "ARMASTEEL" and "SHELL CASTINGS."

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

For convenient, dependable clutch operation...



...the swing is to AIR!

A good example of how air-operated clutches are used in modern heavy-duty machinery may be found in the current MASTERLINE No. 24 Automatic Production Lathe made by Gisholt Machine Company, well-known machine tool manufacturer located at Madison, Wisconsin.

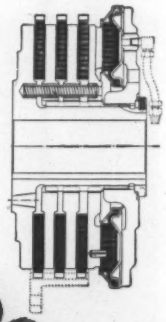
The No. 24 Automatic Lathe incorporates a Twin Disc PO-114 Air Clutch for disconnecting the primary V-belt drive.

The rugged, heavy-duty construction of the PO Air Clutch—plus its high torque capacity—prompted this choice for the heavy-duty automatic lathe . . . but there are other reasons, too. Twin Disc PO Air Clutches offer:

- **A complete range of sizes . . . from 8" to 36" . . . to 127,100 lb.-ft. in torque capacity.**
- **Triple-plate, double-plate, and single-plate designs . . . to meet the widest variety of requirements.**
- **Clutch mass properly distributed in relation to friction area . . . for long life on high energy loads.**
- **Compact and rugged construction . . . with unusually narrow width for replacement of old-style clutches without extensive redesigning.**

Latest models in the long-established, job-proved Twin Disc PO Air Clutch line are the new 8", 10" and 11⅜" sizes. These incorporate an exclusive cartridge-type diaphragm of long-lasting reinforced neoprene which eliminates leakage. They provide constant torque capacity without adjustment . . . and are self-compensating for wear.

Like all Twin Disc PO Air Clutches, these new sizes prove excellent wherever the convenience of remote control is desired or necessary.



TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC

Friction Clutches and Fluid Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

Circle 486 on Page 19

MACHINE DESIGN

December 12, 1957

In the Highest Spirit

ANYONE for a trip to the moon? Five years, or perhaps even five months, ago the general public might have labeled such a question as the mark of a crackpot or comedian. But today —well, two sentinels circling endlessly overhead bear mute witness to the reality of man's achievement.

The successful launchings of Soviet satellites have met with mixed feelings all over the world. There is no denying that we have lost prestige in the race for space and will have to redouble efforts if we are to catch up—and go ahead. But whether we like to admit it or not, one fact stands out: The Sputniks are magnificent engineering achievements.

Few events in our history have so completely captured the public interest as the arrival of these planetary travelers. However, underlying that interest has been an uneasiness; a fear of the unknown, of what man has bitten off for himself, of the possible military advantage gained by a potential aggressor.

No one can calculate the total effect all of this has had on John Q. Public. But of one thing we can be sure. Any plan to catch up in this crucial race for technical superiority will require his wholehearted support. This endorsement will not be blindly given. He's going to be asking a lot of questions about a lot of things—and he's going to want, and expect, truthful, realistic answers.

For engineers, the opportunity is one of first magnitude. The basic facts of space flight are relatively simple and have been known for some time. By giving their ear and attention to the public as informed "consultants," engineers can help to dispel some of the fears, doubts, and tensions of those around them. By word as well as by deed, they will not only be making a valuable contribution to national security but will be taking a giant stride forward in the direction of the status they seek. For it is such conduct—unselfish service to the public—that is in the highest spirit of the true professional.

Leo F. Spector

ASSOCIATE EDITOR

How to Measure
Engineering Department Efficiency

. . . a fast, accurate method of making a time allocation study

USUAL objective of timing engineering activities is entirely different from that of timing production operations. Factory operations are usually of a repetitive and fairly simple nature. After proper time study, a "standard" time can be established during which one operational cycle can be performed. This standard time is then used to predict hourly output, manpower requirements, labor costs, etc.

Due to the complex, nonrepetitive nature of engineering activities, time study in the usual sense is useless and is replaced by a study of time allocation. This is, basically, a study to determine the percentage of the engineering day spent on each of the various activities carried on—designing, planning, research, drafting, etc. The usual way to study such a complex operation is to keep a running check of the engineer's day, recording what he works on at each moment. The results of the study can then be used to predict manpower needs, measure departmental efficiency, indicate necessity of reassigning jobs, etc.

Such a continuous study, if performed by a second person capable of judging what is being

Work Sheet — Date Monday-10/1/57

Observer Joe Doe — Stations 1 2 3 4 5 6 7 8 9 — Totals

Item	Totals
A Normal work cycle	80
1. Designing	29
2. Calculating/Computing	12
3. Planning/Thinking	23
4. Consultation/Group discussion	5
5. Library research	3
6. Report writing	7
7. Other (see other side)	1
B Idle personal	62
C Routine activities	35
1. Typing	25
2. Filing	23
3. Expediting	17
4. Co-ordinating	4
5. Estimating	1
6. Facility processing	4
7. Drafting	6
8. Scheduling	5
9. Tracing (graphs/charts)	12
10. Processing paper work	5
11. Receiving instructions	5
12. Reading trade journals	7
13. " reports (technical)	2
14. " company procedures	9
15. " newspapers	9
16. Waiting for blue prints	6
17. Phoning	3
18. Miscellaneous (see other side)	320

Fig. 1—Work sheet for making observations during trips through the engineering department

By RICHARD PAULSON

Consulting Engineer
La Jolla, Calif.

done, may easily cost more than it is worth. In addition, resentment toward the study is certain to be felt by the person being timed. With someone watching him constantly throughout the day, the engineer is likely to skip the time he normally devotes to personal items and spend his time in a highly productive, but personally unsatisfactory manner. Engineering executives who have made studies of their own day, by keeping an account of what they did during each hour, usually find that the day is highly productive due to the self-imposed monitoring, but is not a "normal" day by any means and is nearly useless for planning or measuring purposes.

Due to the cost, inaccuracies, and personnel problems associated with continuous time-allocation studies, a technique has been developed to accomplish the desired objective by a simple form of statistical sampling. This method is based on the theory that studies taken in quantities, recording what each man is doing at one particular time, will accurately indicate how a group of people are spending their entire working day. This is the true purpose of time-allocation studies—determination of departmental efficiency and pointing out specific activities that may contribute to low efficiency.

To measure efficiency or productivity, the job to be done must be defined. It must be decided which of the activities that are associated with an engineer's job should be done by him. Many

Definition of Terms

Time Study—A stop-watch study of a standardized, repetitive operation. Objective is to find number of operations that can be performed in one hour or day. Use is for finding labor cost, manpower requirements, production quantities from a given time, etc.

Time-Allocation Study—A timed, continuous study of nonrepetitive operations made by recording the time spent on each individual activity. Objective is to determine utilization of time, analyze a job, or to establish historical data for estimating time for future, similar jobs.

Ratio-Delay Time-Allocation Study—A nearly simultaneous observation of a random number of people (part of a larger group), recording what each is doing at the time. Objective is to determine overall or average utilization of time for each activity carried on by the group.

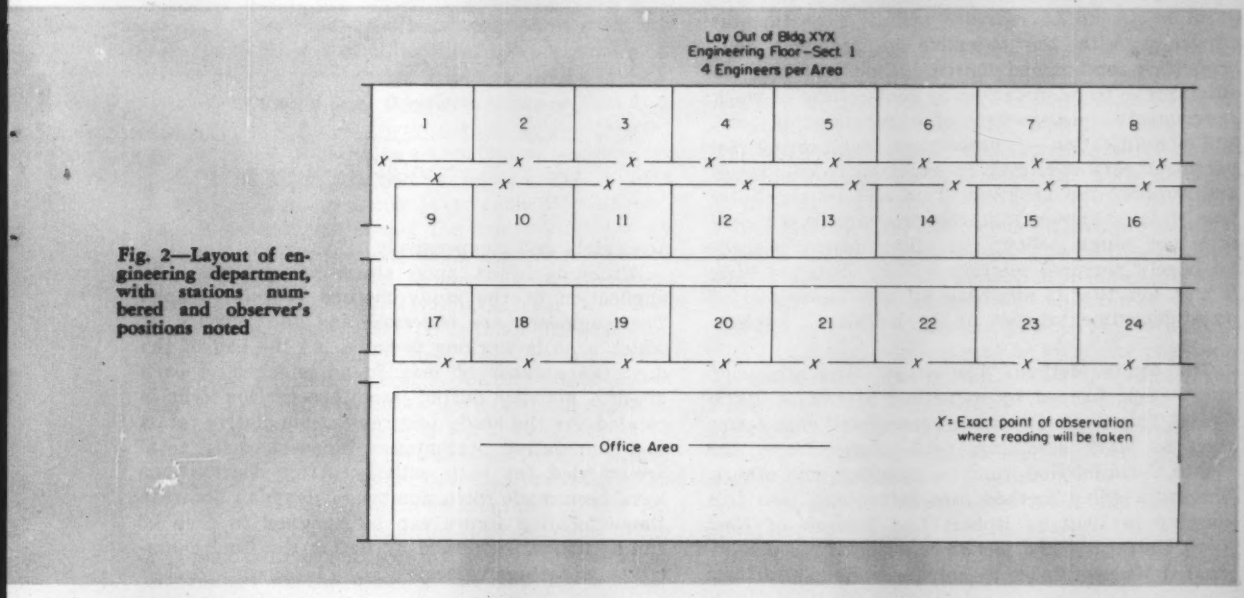


Fig. 2—Layout of engineering department, with stations numbered and observer's positions noted

activities that are associated with his job may or may not be justifiably considered productive engineering activities, depending upon whether or not individuals with less training and skill are capable of handling them.

What is productive engineering time? Thinking, studying, research, analyzing, reading, designing, drafting, checking, consultation, sharpening pencils, or plain day dreaming may all be considered productive. Only by determining the actual percentage of the engineering-department day that is utilized for each of the many activities going on, can any realistic appraisal of relative efficiency be made.

Preparing for the Study: A study of time allocation can be easily made on a departmental basis. A record of activities of individuals, picked on a random basis, will accurately indicate what is being done within the department. If such a study is made daily for a matter of a few weeks, very accurate results may be obtained and a study made of operations performed and percentage of total time spend on each individual operation.

Naturally, since engineers are both human and intelligent, there is likely to be a tendency to appear productive when the observer comes by. It is beyond ordinary reasonableness to expect that three men standing around a water cooler will not disperse when they see the observer coming. For this reason, the work areas are numbered and only about half are checked on each trip. The areas to be checked are selected on a random basis. Random checking of only a half also permits the check to be made much faster, reducing the tendency of the personnel to turn to other work.

To a very large degree, the success of such a program is tied in with proper indoctrination of the personnel. The program should be explained in detail, how it will be handled, by whom, and most of all, why. It should be pointed out that the program is set up to measure overall departmental efficiency, with the objective of reducing nonproductive and nonengineering time. As long as efficiency is to be increased by reallocation of work assignments, reassignment of nonengineering jobs, and simplification of procedures, engineering department personnel may be expected to co-operate and support the program. This will be especially true if it is known that the program is not part of a get tough policy; that time normally spent on purely personal matters will be curtailed little if any, and that in any case, all results are plotted on a departmental, not on an individual, basis.

The Study Method: The actual time allocation study is performed by a method known as Ratio Delay. This method has been associated with terms such as work sampling, ratio observations, the Monte Carlo method, random sampling, and others. The ratio delay method was introduced into this country in 1940 by Robert Lee Morrow of New York University and has since successfully demonstrated its usefulness in solving various problems accurately and inexpensively.

Although based upon statistical systems, the application of the study method is quite simple. The engineers are observed and the activity at which each is working is noted. At the end of the day, the number of men found engaged in each specific activity during each observation trip is totaled. As the study progresses, cumulative totals and cumulative percentages for each daily total are carried for each activity. After observations have been made for a number of days, an accurate time-allocation figure can be assigned to each of the activities performed by noting the final cumulative percentage value.

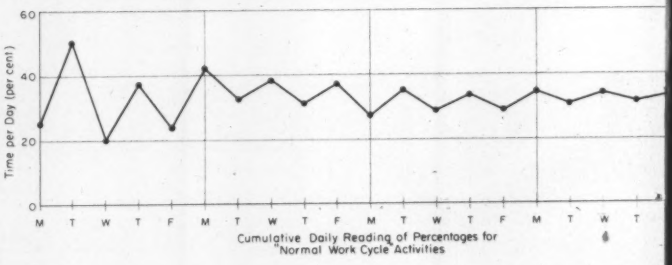
Summary Count Sheet

Observer *Joe Doe*

Item:	Day *Monday* Daily Count	% of Total	Cumulative Count	%	Day *Tuesday* Daily Count	% of Total	Cumulative Count	%	
A Normal work cycle	80	25	-	-	220	78.7	300	50	50
1. Designing	29	9			48		77	12.8	
2. Calculating/Computing	12	3.8			33		45	7.5	
3. Planning/Thinking	23	7.2			37		60	10	
4. Consultation/Group discussion	5	1.6			28		33	5.5	
5. Library Research	3	.9			22		25	4.2	
6. Report writing	7	2.2			52		59	9.8	
7. Other (see other side)	1	.3			0		1	.2	
B Idle personal	62	19			50	17.7	112	18.8	18.8
C Routine activities	178	56			10	3.6	188	31.2	31.2
1. Typing	35	11			4		39	6.5	100%
2. Filing	25	7.9			1		26	4.4	
3. Expediting	23	7.3			-		23	3.8	
4. Co-ordinating	17	5.3			-		17	2.8	
5. Estimating	4	1.3			1		5	.8	
6. Facility processing	1	.4			2		3	.5	
7. Drafting	4	1.3			-		4	.6	
8. Scheduling	6	1.8			-		6	1.0	
9. Tracing (graphs/charts)	5	1.6			2		7	1.2	
10. Processing paper work	12	3.8			-		12	2.0	
11. Receiving instructions	5	1.6			-		5	.8	
12. Reading trade journals	5	1.6			-		5	.8	
13. " reports (technical)	7	2.2			-		7	1.2	
14. " company procedures	2	.6			-		2	3	
15. " newspapers	9	2.8			-		9	1.5	
16. Waiting for blue prints	9	2.8			-		9	1.5	
17. Phoning	6	1.8			-		6	1.0	
18. Miscellaneous (see other side)	3	.9			-		3	.5	
	320	100			280	100	600	100	

Fig. 3—Above—Summary count sheet for determining cumulative percentage values for each activity.

Fig. 4—Chart for plotting cumulative percentage readings of one specific activity. In this case, the "normal work cycle" activity readings are plotted.



RESULTS OF ENGINEERING DEPARTMENT STUDY

A time-allocation study was made of the engineering department of the XYZ Mfg. Co. Purpose of the study was to determine the productivity of the department and to locate and measure any nonproductive activities.

The study was discontinued at the end of 20 days, since the curves had reached a point of stability and further observations were considered to be of little value.

Engineers were found to be devoting the time of each day to various activities as follows:

Designing	14	%
Computing	5	
Compiling information	3	
Consultation (meetings)	6	
Library research	2	
Other (break-down attached)	4	
Idle personal	20	(this is much too high and should be thoroughly investigated)
Filing	15	
Typing	9	
Expediting	7	
Estimating	1	
Scheduling	1	
Follow up	1	
Routine drafting	6	
" computation	4	
" graph work	2	
TOTAL	100	%

The results of the study shown above indicate that the engineers are spending 46 per cent of the day (or just under four hours) on clerical and nonengineering tasks. With these superfluous activities pinpointed and measured, steps can now be taken to alleviate this condition.

Fig. 5—Typical analysis based upon study

Among the main advantages of this method are the ability to obtain facts at one-third to one-sixth the cost of continuous observations, and the opportunity to acquire facts not usually secured by any other means.

As far as disadvantages are concerned, there seem to be none, except those applying to all time-measuring methods. The tendency for people to become uneasy when being observed doing their work can be overcome by proper indoctrination. In fact, a study such as this must be completely above-board from the very start. All concerned must be made fully aware of the reason for such a study. Otherwise, suspicion and resentment can create any number of difficulties.

Records and Forms Required: Assume that it is desired to make a study within an engineering department to determine utilization of engineering time. First, a work sheet is devised, Fig. 1, with a list of as many items as possible that are expected to be found among the engineering group's activities. Notice that the items shown as "routine" are comparable to what is normally considered as avoidable or unavoidable delays, that is, these are the "nonproductive" operations. In some engineering departments, these may be considered as normal engineering duties, and the listing shown should be considered only as a typical example.

Each of the items on the work sheet should be defined on data or job breakdown sheets as clearly as possible, so that observers and individuals being observed agree on identification of the activity as it is being recorded. For example, when a person is observed drawing sketches, it must be determined at the time of the reading whether this person is "designing" (Item A-1), or "drafting" (Item C-7). Another case might concern an individual reading a newspaper (Item C-15). If he is reading the comics, it will have to be considered as "Idle Personal" (Item B). If it is technical information, it will remain as Item C-15.

Since sampling will be done at random, each run will not be started at the same place. A layout of the department is made, Fig. 2, and each engineering desk is numbered or identified to correspond to the stations on the work sheet. Each station is marked with an *X*, so that the observers will know the exact location for taking a reading.

Length of time required to complete the study and the amount of accuracy expected from the readings must be determined. For example, it is assumed necessary to run the study for four weeks, at which time it is expected that readings will have the accuracy desired. A sheet is maintained to tabulate cumulative daily readings, Fig. 3, and also a number of charts for plotting the individual activity readings, Fig. 4.

Making the Study: Observers make a quick tour of the department and note the work activities on the work sheets as they occur. Perhaps a half hour or so later (no preplanned time, since it is to be random sampling) another tour is made, but beginning at a different point than the first. This will continue throughout the day with no two succeeding tours following the same pattern.

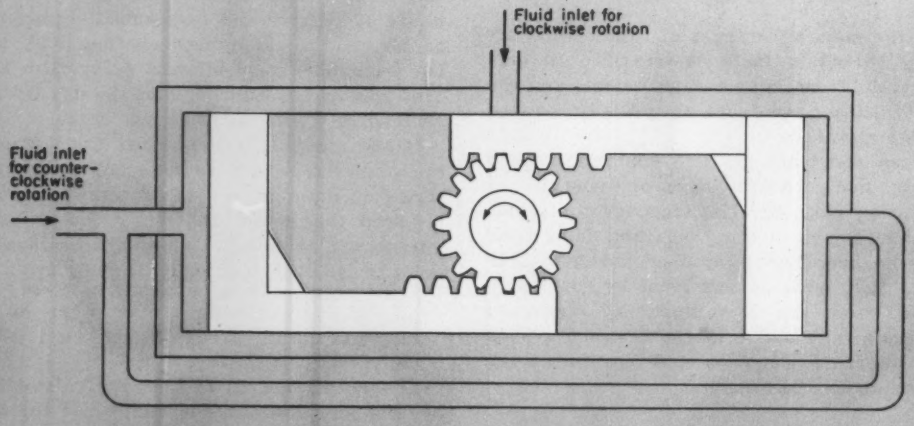
If the study is well planned (as it should be), the observers will have determined beforehand a series of different routes or tours which will be followed throughout the study. Assuming 20 engineers are involved, each might be identified by number and each tour planned as follows:

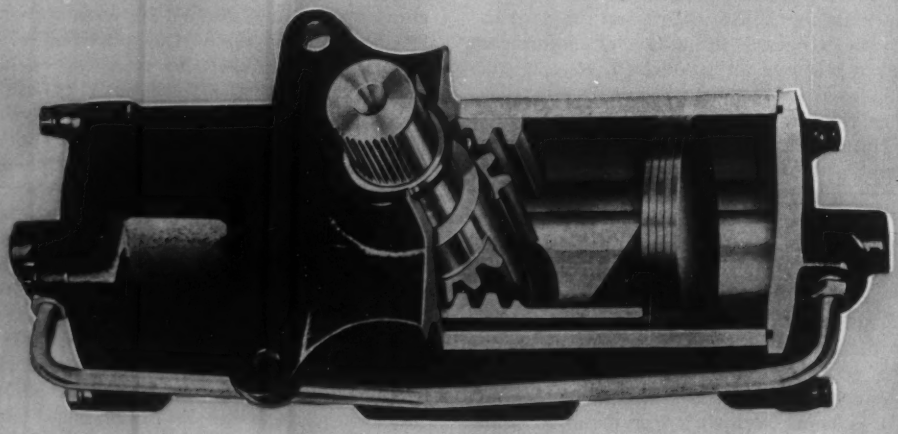
Tour A = 15, 3, 8, 4, 6, 9, 12, 18, 1, 5, 7
Tour B = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20
Tour C = 19, 17, 15, 11, 16, 13, 14, 1, 18
Tour D = 11, 2, 4, 6, 8, 10, 5, 9

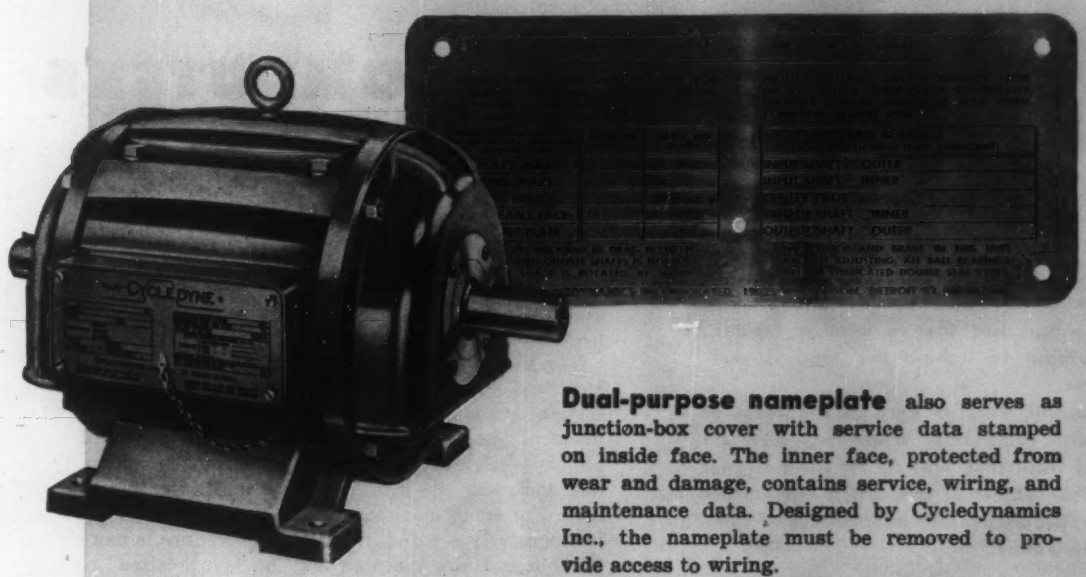
The actual length of the study is determined by how long it takes the values for the activities selected as most important to stabilize. A separate chart must be maintained for each activity studied, Fig. 4, but not all of the activities will warrant keeping records on. The readings begin to form a pattern after the first week of study. When the study has been completed, an analysis is made, Fig. 5. The analysis, based upon the completed study, quickly and accurately determines the true condition of the engineering department. As in the example given, the analysis may offer definite proof that assistance should be given the engineers in the form of clerks and technicians, and about how many will be required. On the other hand, the analysis could give entirely opposite results, revealing excellent utilization of available engineers and thus indicate that productivity of the department cannot be increased without additional engineering manpower. In either case, the analysis is frequently exactly the logical justification necessary to sell plans to skeptical management.

scanning the field for *ideas*

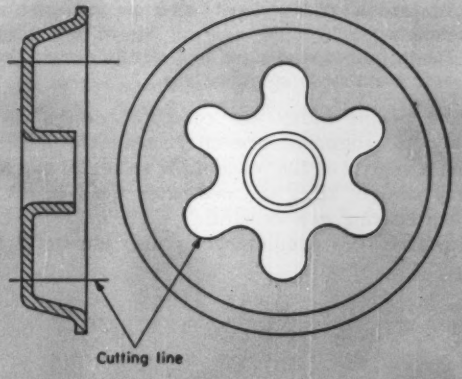
Opposed, internal gear rack elements are used to provide linear-to-rotary motion conversion in a power cylinder developed for hydraulic or pneumatic service. The design, developed by Thompson Products, Michigan Div., has two pistons, each with an integral rack projecting from the inner face. The two racks mesh with a piston mounted in the center of the cylinder. Fluid entering the ends of the cylinder forces the pistons and racks inward, turning the pinion and its shaft. Reverse rotation is obtained by forcing fluid between the pistons.

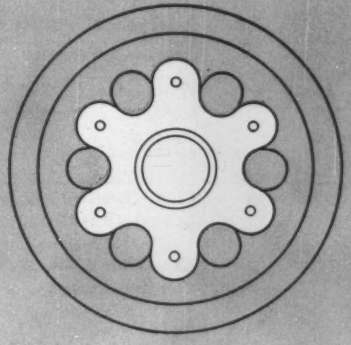


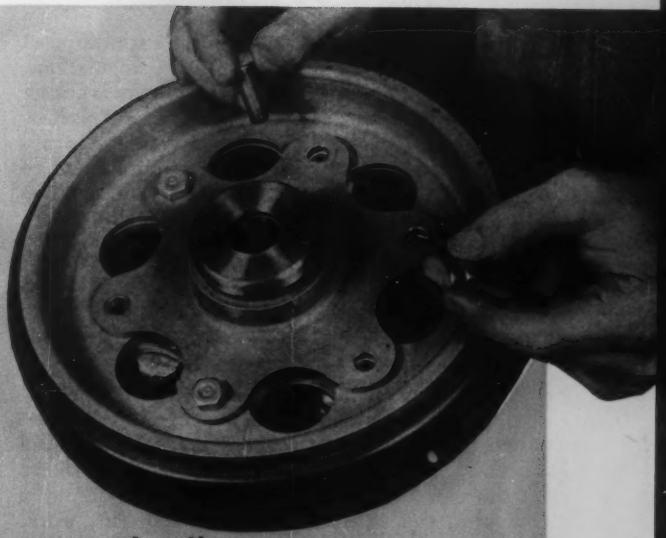




Dual-purpose nameplate also serves as junction-box cover with service data stamped on inside face. The inner face, protected from wear and damage, contains service, wiring, and maintenance data. Designed by Cycledynamics Inc., the nameplate must be removed to provide access to wiring.







Jigsaw construction of wheel hub and flange elements offers advantages in production and assembly operations. In this design, mating hub and flange halves are produced as one piece, then cut apart in a gear-like design. By rotation of the hub half, the "teeth" of hub and flange overlap to provide contact surfaces for joining by bolts. The design was developed by Rapids-Standard Co. Inc. for a demountable-rim wheel.

USING DIGITAL COMPUTERS

Design engineers often find that paths to finished products lead through masses of routine calculations. They're essential, but they're also a burden. Anything to lighten the load is welcome.

Today, help is here in the form of digital computers. What they now do and what they will do for the designer is the subject of this article—the practice, problems, and possibilities of computerization.

BEFORE computers, the design engineer used to spend a lot of time on hand calculations. Often, this work consumed all his working day. Now, however, computers can assume most of this burden. One result is the opportunity to upgrade design men to jobs which require them to think creatively 90 per cent of their working time instead of spending 40 per cent in standard calculations.

Current Practices

The design engineer is frequently required to specify properties and capabilities of proposed new products. He often does this by reviewing previous designs. If something close is available, he scales up the new design from the old one. Without a computer, this is time-consuming, slide-rule work.

For example, in electrical rotating machinery, a new generator may be "ratioed up" from an old design. However, special requirements such as low harmonics, high efficiency or an odd voltage may take still more time. If the design is a motor, the torque requirements may require tedious design work and difficult decisions, since high starting torque and low inrush current are opposite requirements. Also, calculating torque-speed curves is slow work with complex numbers.

Once the "slide rule slavery" is over, the engineer must fill out drafting instructions and then manufacturing instructions.

The word *ratioing* is important because all large electrical equipment manufactured in "lines" has certain available punchings and a choice must be made of one for a new design. The job is one of analysis—choosing the most appropriate punching, and analyzing the rating to see if it fits the punching. For small machines, where new punchings are inexpensively created, the design procedure is more flexible and a new design may be "synthesized" to meet customer requirements.

Search and Synthesis: Now let's see what the computer can do in this case. First, consider the problem of a suitable design. Most electrical machinery manufacturers have a wide variety of designs already prepared and it is only a matter of finding the one most nearly suitable. A computer makes possible two courses of action:

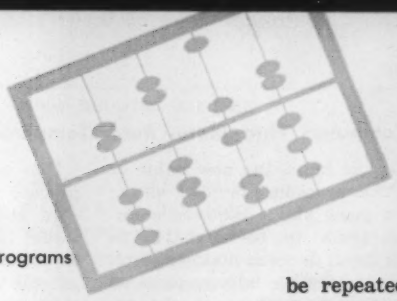
1. Prepare a "filing-clerk" deck to seek out a design.
2. Ignore previous designs and simply design the new machine to specifications.

Most people today use computer design decks simply to augment presently available designs. When a search of file books fails to reveal the necessary design, then the computer deck is set to work preparing new designs.

However, the computer can also eliminate the

Table 1—Typical Inputs and Results

	Computer Inputs	Computer Outputs
Analysis	Wire sizes Punching dimensions Rating	Flux densities Losses/efficiency Excitation requirements
Synthesis	Flux densities Losses allowed; Efficiency Excitation allowed Starting current	Wire sizes Punching dimensions Weight Cost



By JOHN R. M. ALGER
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manual search of file books. This is done by successively eliminating specified variables, using the choice or logic circuits. A desired product may be a synchronous motor design of 1200 hp, 6 poles, 60 cps, and 0.8 power factor. The computer deck is set up to eliminate one variable at a time. First, the horsepower rating is compared to every other rating, one at a time. This comparison might simply be subtracting 1200 from the compared rating. Naturally, when 1200 is reached, a zero is obtained which signals the computer to shift to a new location (storage) instead of proceeding further on horsepower.

The new location causes the computer to search poles. When 6 is reached, in this case, another shift occurs. Eventually (actually in, say, 10 sec or so), we arrive at a storage location for which horsepower, poles, cycles and power factor are correct. This location then directs the computer to point out a series of numbers designating all the designs that meet the desired specifications. If the computer were large enough, the actual designs themselves would be provided. Thus, the design engineer would have all previous designs that meet certain of the specifications.

What the computer does, essentially, is to cull over all the available designs, gradually eliminating until all desired specifications are met. It would be entirely possible to establish a variable number of specifications. For example, if 6 criteria were set, but did not yield a design, the process could be repeated with 5 criteria. If a wider spread of designs is desired, only 3 or 4 specifications need be set.

Presuming the computer to have gone through the files without success, the design engineer then asks the computer to design a machine for him—essentially a process involving synthesis as shown in Table 1.

Synthesis consists essentially of obtaining a material list and design instructions from specifying the required output. Analysis is considered to be the reverse.

Computer decks can be set up to combine synthesis and analysis. For example, a synchronous motor may be computer-designed in a certain punching, except that the computer is asked to try various damper windings in order to come up with acceptable starting and maximum torques. Once the computer has provided the design engineer with a generally suitable paper machine, he will ask further for calculation of many ranges of data such as:

Reactances	Vee curves
Time constants	Regulation
Harmonics	Losses
Load-saturation curves	Torque-speed curves

Program: The digital computer has advanced tremendously in the last five years. Programming a computer is now extremely simple so that the time spent is mostly used in setting up the equations and debugging. General procedure is shown in Table 2. Preparation of a major design deck for a machinery section may require between 300 to 600 engineering man hours. The time would be divided up approximately as Table 2 shows, except that the coding would be done by an engineering assistant working with the engineer.

For the computer specialist it is sufficient that the results and program be in computer language. For example, 04 1950 1060 might mean "Add core loss to copper loss." But for the design engineer, and all others not continuously close to computer technology but primarily interested in the results, the above step should be printed out as stated: Add core loss to copper loss. Equipment to perform this step automatically is gradually becoming available. When fed the written instruction "Add core loss to copper loss," the machine will know what to do. For its own consumption, the machine may have to translate to computer language first, but it will do this automatically. The results will be a printed statement that reads:

1. Copper loss in stator	1500 w
2. Core loss in stator	700 w

In computer language, the results might read 5315000000, 527000000. To translate, a position

Table 2—Allotment of Time in Computer Programming

Time (per cent)	Operation
*	1. Prepare a design method.
10	2. Establish philosophy of solution on computer.
20	3. Set up equations in the desired order.
20	4. Program (translate solution into computer language).
10	5. Punch program deck.
40	6. Run deck through machine and debug.

*Previous work

Example—Two Computers Find Motor Rotor Temperature

Less complex computers, like those of early design, are able to do arithmetic and thereby lift many burdens from the engineer because many of his calculations reduce to addition and subtraction. For example, suppose the temperature of a motor rotor is to be calculated with the equations:

$$r = r_0(1 + at) \quad (1)$$

$$Q = i^2 r \quad (2)$$

$$t = RQ \quad (3)$$

where:

- r_0 = Rotor resistance at base temperature
- r = Rotor resistance at temperature t
- a = Temperature coefficient of resistance
- i = Rotor current
- Q = Power loss in rotor
- R = Thermal resistance between rotor copper and air
- t = Temperature of rotor copper

A temperature t must be assumed to calculate r. With this resistance Q is calculated and then t. If t is a poor guess initially, the calculated value of t will be poor and recalculation is necessary, using a new answer for t.

For example, let:

$r_0 = 1$
$a = 0.004$
$i = 10$
$R = 0.10$
t (initial) $= 2$

Substituting in Equations 1, 2, and 3:

Step 1
$r = 1[1 + (0.004 \times 2)] = 1.008$
$Q = 100 \times 1.008 = 100.8$
$t = 0.10 \times 100.8 = 10.08$

Step 2
$r = 1[1 + (0.004 \times 10.08)] = 1.0403$
$Q = 100 \times 1.0403 = 104.03$
$t = 0.10 \times 104.03 = 10.403$

Step 3
$r = 1[1 + (0.004 \times 10.403)] = 1.0416$
$Q = 100 \times 1.0416 = 104.16$
$t = 0.10 \times 104.16 = 10.416$

This process can be continued indefinitely, but since the change in t between Steps 2 and 3 is less than 0.2 per cent, a sufficient answer is available.

When these steps are performed on an early digital computer, the operator must look at the answer for t between each step and feed back into the computer, by hand, the new value of t. This procedure is good, as far as it goes, but it requires a human brain to be available at each small decision-making point.

A considerable improvement on the earlier machine is the internally programmed machine which can:

1. Make decisions (i.e. choose one of any number of possible paths of next action)
2. Implement the decisions (i.e. take the next action)

In the problem just worked, the newer machine will compute a trial value of t, calculate a step, compare the answer to the previous one, recalculate if necessary, or stop if the answer is as close as desired to a "true" answer.

Process	Program
1. Calculate an initial value of t.	$t = 2$ (assumed)
2. Calculate t (go through Step 1).	$t = 10.08$
3. Calculate the per cent change in t.	Change, $\% = \left(\frac{10.08 - 2}{2}\right) 100 = 404$
4. Is this change less than 0.2 per cent?	$404 - 0.2 = +$
5. Since the answer is no (i.e. plus), put the calculated value of t back and recalculate t.	$t = 10.403$
6. Calculate the per cent change in t.	Change, $\% = \left(\frac{10.403 - 10.08}{10.08}\right) 100 = 3.2$
4. Is this change less than 0.2 per cent?	$3.2 = 0.2 = +$
5. Since the answer is no, put back recalculated t and recalculate again.	$t = 10.416$
6. Calculate the per cent change in t.	Change, $\% = \left(\frac{10.416 - 10.403}{10.403}\right) 100 = 0.125$
7. Is this change less than 0.2 per cent?	$0.125 - 0.2 = -$
8. Since the answer is yes (i.e., minus), stop and provide the answer.	

The computer can be told to proceed as the table shows.

In such a simple problem, it would have been simpler to put Equations 1 and 2 into 3 and get the exact value 10.444. But in the usual thermal circuit problems of machinery, a network of resistance elements is involved for which the equations become exceedingly complicated if the exact solution is attempted. However, an "iterative" technique, as illustrated, works simply and rapidly (electronic speed). The design engineers need only specify the equations and philosophy of solution in words (as the example shows). An engineering assistant will pick up the problem from there and carry it out, giving back the answers the computer provides.

decoder is needed and the decimal notation must be remembered.

Capacity and Capability: Especially in large companies, computer time is now readily available. Computer centers at universities and business machine companies also offer computer facilities. Many problems or parts of problems can be solved immediately. Decks are available for obtaining roots of polynomials of any order, and for solving simultaneous equations, algebraic or differential. Further, the special-purpose program decks of many company components are on hand and available.

Computer decks can be designed to handle wide ranges of machines. Recently, the electrical design and critical speed were needed on a new high-speed aircraft generator. It happened that a deck was available which provided critical speeds, but the deck was originally intended for shafts of many times the size of the aircraft generator. Likewise, an electrical excitation calculation deck was available, but it was normally used in 10,000 to 50,000 kva generators. It readily provided the same data for the 40 kva machine.

Problems Computers Pose

Programming: Naturally, the computer poses some problems of its own. One is: Who is to program the computer? It is generally preferable that all engineers, both managers and specialists, acquire the ability to supervise the programming of their problems rather than allocate the entire problem to a computer staff. This policy holds the computer staff to the economical minimum needed to perform routine programming and to operate the machine.

Design engineers should be asked to supervise and carry out the computerization of existing calculation methods. Development engineers should carry on new work to capitalize on the accuracy that can be obtained. Management must realize the time and money involved in programming and debugging computer decks.

This requires first-hand knowledge of computer language. Roughly 8 to 10 months must be available to prepare the engineering force of a medium-size company to use a medium-size, internally programmed computer.

Assignment: Sometimes an alliance of the accounting and engineering forces facilitates the computerization of work. This may start off as an agreeable arrangement but usually becomes unworkable due to differences in the requirements of engineering and finance. Engineering usually needs computer time at odd hours, and immediately or not at all. This is the nature of requisition and proposition work. Accounting requires the same time regularly (i.e., the payroll must get out).

Co-operation can perhaps be enhanced by allotting to engineering some small but regular time which must always be paid for even though not used. Generally speaking, as the computer load grows, engineering and accounting should go their separate ways. Further, a scientific computer does not have the same fittings as a straight business machine.

Confirmation: One problem may arise which has not yet been seen because of computer newness. That is the question: What is the computer doing? The origins of design methods tend to become obscure. As a result, engineers use rules of thumb and design equations by rote rather than knowledge. This is a trap, because assumptions made can vitiate the use of such results in certain cases.

An example is the averaging method of calculating speed torque curves for synchronous motors. The torque dip at half speed is not correctly represented by the calculation method and could lead to a half-speed crawl in test if not recognized in time.

The computer makes greater, not less, the possible danger of pat design methods. For now, the computer has the brains and may tend to seem inviolable. It is easy to design by computer without thought to the limitations of particular design decks. The assumptions and limitations of the decks should be carefully documented. Such documents should be required reading for persons using the decks.

Correction: Ease of computerization and usefulness of results have increased one burden rather than decreased it. That is debugging. One may program a problem, and if it is at all complicated, the answers will not agree with check points at the first or second try. Therefore, in computer decks of any size, it is well to use the means provided to self-check the decks.

If, by error, an operator tells the machine to do something it cannot, for example, it will stop and state its problem (in lights) and tell where within the computer deck the trouble lies. Almost any error can be detected by the machine itself so it can inform the operator of the trouble and show where it is. Of course, the next step is self-correction within the machine.

Cost: It takes courage for management to accept the immediate high cost of a computer because it is not possible to balance the suddenly increased cost against correspondingly reduced manpower or increased efficiency. One cannot check off this and that job because the computer arrives. New jobs are created. The computer must be accepted as progress for which the payoff will come gradually.

The cost of computerization is roughly $50 per

hour for a medium-size, internally programmed machine. However, with proper preparation of input material and training of personnel, the time invariably can be well spent.

Possibilities for Computers

Refinement of Estimates: Prior to the introduction of computers, lack of manpower and lethargy caused some items in engineering quotations to be estimated or ignored. Now, with computers, it is easily possible to study the effects on performance of varying each of the input data. Effects one at a time, two at a time, or n at a time may be studied.

Design Optimization: A new possibility opened up by computerization is optimization of design within allowable time limits. In design quotations, time permitted the design engineer to make only one or two quick calculations and then a decision. By computer he can obtain all the possible designs or an optimized design from an optimizing computer deck. A common optimizing criterion is cost. For military applications it may be weight or output.

An example of design optimization is that of aircraft generator weight which varies with reactance. An optimizing deck provides the lightest weight machine. Without the deck, time would not permit making enough comparable designs to be certain of obtaining the optimum.

System Optimization: Further, the computer opens up to the design engineer the possibility, eventually a competitive necessity, of system optimization. Any machine is but a system component. Several machines plus controls often constitute the package sold. An optimum system would meet the system specifications on cost, for example, and one other property, the two being considered simultaneously. Properties other than cost could be losses, response time, or output (rated and maximum).

A Look Ahead: It will not be long before routine designs are carried out completely on a computer. Starting with customer requirements, the computer will furnish manufacturing instructions and drawing numbers. Actually, causing the computer to issue drawings is a procedure now under development.

The advances of digital programming into manufacturing, in such forms as a card-instructed lathe or milling machine, suggest the idea that the customer may eventually specify his requirements and actually receive his neatly optimized apparatus from a completely automatic factory which devours instructions and raw materials to produce end products directly.

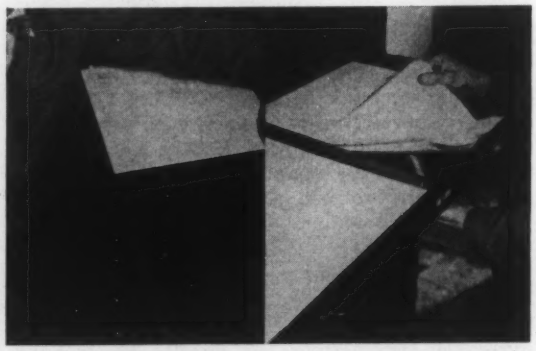
Tips and Techniques

Lines on Corrected Sepias

The difficulty of producing clean, dark lines on sepia after the undesired portion of the drawing has been bleached out can be readily overcome. The desired lines are drawn on the sepia, right over the lines to be removed, just as if using a clean sheet of paper. Then, the old linings are bleached out, leaving clean, dark lines. Using this method, it is not necessary to worry about tearing the soft, wet paper nor to wait until the paper dries as the drawing is finished. Good scale is insured as the predrawn lines will shrink with the sepia during bleaching.—ED L. GOULD, *Hickman Mills, Mo.*

Locating Drawings

Addition of a 1-in. diam hole, located in the bottom and title block corner of each tracing compartment of tracing-file drawers, provides a convenient method of locating tracings anywhere in the pile. This hole eliminates "dog-eared" corners on tracings, because the title block corner of the



entire pile is lifted from the compartment by inserting a finger through the hole. The hole is easily installed using a 1-in. diam hole saw.—THOMAS C. ROSTRON, *Schramm Inc., West Chester, Pa.*

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Ground Rules for Determining or Comparing

BEARING CAPACITY RATINGS

What they are

How they are determined

Their use in bearing selection

By LEO FIDERER
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DIFFERENT methods are used to give load ratings for bearings made by different manufacturers. Thus, a comparison of the capacities of similar bearings made by different manufacturers is a difficult task. However, an understanding of the principles underlying the standards by which bearing-capacity ratings are established will simplify the selection process.

Fatigue

If a load on any structure is applied repeatedly and alternately from opposite directions, it causes a continuous reversal of stresses. Gradual deterioration of the material due to these stress reversals eventually causes breakdown of the material structure. This fatigue failure may occur although the applied stress is well below the elastic limit. The number of stress repetitions or stress reversals is the critical factor in fatigue failure.

When a ball or roller bearing is running under load, each point on the race over which the rolling elements pass is alternately under compressive and tensile stress. Therefore, each revolution causes a definite number of stress reversals which will eventually lead to bearing failure. If the bearing is correctly lubricated, mounted, and protected from dust and other foreign matter, fatigue is the only cause of failure.

Nomenclature

B	= Bore diam, mm or in.
b	= Load-ratio exponent
C	= Specific dynamic capacity, lb
C_s	= Specific static capacity, lb
D	= Outside diam, mm or in.
D_m	= Mean diam, mm or in.
F_a	= Axial force, lb
F_r	= Radial force, lb
L_h	= Bearing life, hr
L_n	= Fatigue life, millions of revolutions
N	= Speed, rpm
P	= Equivalent radial load, lb
R	= Radial capacity, lb
T	= Torque, lb-in.
W	= Width, mm or in.
μ	= Coefficient of friction

Bearing Life

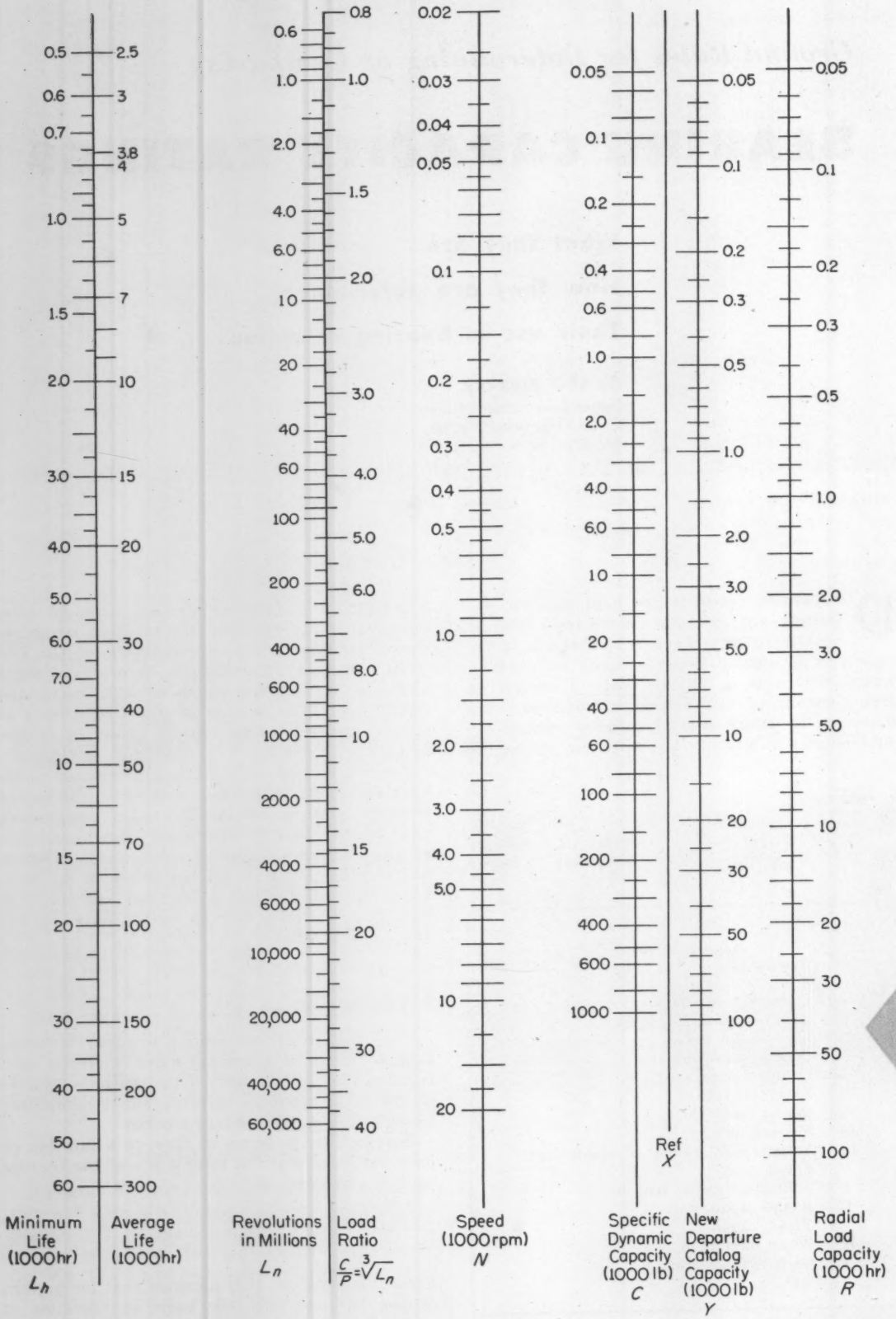
The number of revolutions required to cause fatigue failure of a bearing under a certain load is called the "fatigue life" of the bearing. Because of the large numbers involved, life is commonly expressed in millions of revolutions.

Bearing life, in terms of time, is a function of both the speed and the fatigue life of the bearing and is expressed as

$$L_h = N \left(\frac{L_n}{60} \right) \qquad (1)$$

From this equation, it is apparent that for a given fatigue life and load, the hours of operation of

Fig. 1—Bearing Capacity Nomogram



a bearing are inversely proportional to the speed.

Despite the high precision, uniformity, and quality obtained in the manufacture of bearings, differences in the life of apparently identical bearings are unavoidable, due to manufacturing and material variations. If a large group of seemingly identical bearings are run under the same load, speed, and operating conditions, some bearings will fail early, while others may last four times as long as the average of the group.

Many bearing manufacturers have conducted extensive tests on bearing life. Data from such tests give a fair indication of the percentage of bearings in any group that will reach a certain life. One of two methods of determining life expectancy is used by most bearing manufacturers. Some use the "minimum life" (B-10 life). This signifies that 90 per cent of any large group of bearings of the same type and size will have a life longer than the rated life, and 10 per cent will fail before that life is reached. Other manufacturers use the "average life," i.e., 50 per cent will exceed the rated life, while 50 per cent will fail before the rated life is attained. The average life is five times the minimum life. Before comparing load ratings, the designer has to ascertain, from the manufacturer's catalog, which of the two rating methods is used.

The choice between the two life-rating methods demands special care. For example, in machines that require continuous, dependable service, it would be sound practice to use the minimum life for the basic rating of the bearing. The "average life" implies that there is one chance out of two that the bearing would fail before the rated life is reached.

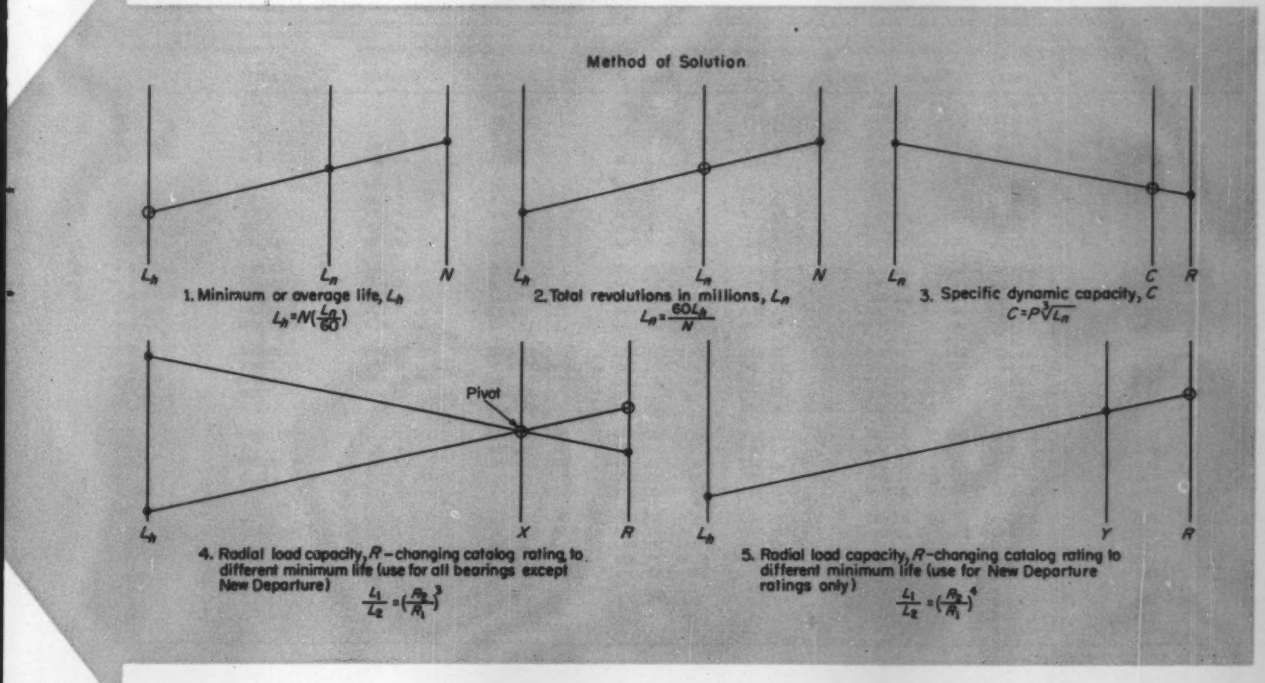
Bearing replacement would not only involve the bearing cost, but also the expense of disassembly and reassembly of the machine. More important, the cost of lost production time, when the machine is stopped for maintenance, is often prohibitive.

On the other hand, in mass-produced items and when the bearing can be quickly and easily replaced, as in automobiles, it is often advisable to use the average life for the basic rating. This

Table 1—Recommended Bearing-Life Values

Type of Application	Bearing Life, L_h (hr)
Instruments and apparatus for infrequent use: Demonstration apparatus, devices for operating sliding doors	up to 500
Aircraft engines	500 to 2000
Machines for short or intermittent operation, where service interruption is of minor importance: Hand tools, hoists, hand-driven machines, farm machinery, assembly cranes, charging machines, foundry cranes, household appliances	4000 to 8000
Machines for intermittent service where dependable operation is of great importance: Auxiliary machines in power stations, work-moving devices on production lines, elevators, general-cargo cranes, less frequently used machine tools	8000 to 14,000
Machines for 8-hr service which are not always fully utilized: Stationary electric motors, general-purpose gear drives	14,000 to 20,000
Machines for 8-hr service which are fully utilized: Machine tools in general, continuous-service cranes, blowers, jackshafts	20,000 to 30,000
Machines for continuous (24-hr) service: Separators, compressors, pumps, roller conveyors, mine hoists, stationary electric motors	50,000 to 60,000
Machines for continuous (24-hr) service where dependability is of extreme importance: Cellulose and paper machines, public power stations, mine pumps, public pumping stations	100,000 to 200,000

Courtesy, SKF Industries Inc.



is especially important when the cost of the product has to be kept at a minimum for competitive reasons.

Table 1 gives the minimum bearing life to be used in various types of machinery. Of course, the designer's judgment has to be used in each decision on bearing life. Generally, the bearing should serve as long as the other machine components.

Relation Between Load and Life

From tests conducted by many bearing manufacturers, a definite relationship between the applied load and the fatigue life of the bearing has been established. If a group of test bearings is run under a constant load, P_1, and another group of bearings of the same size and design are run under load P_2, but otherwise under identical operating conditions, the lives, L_1 and L_2 respectively, may be obtained for these groups. The relation can be stated with fair accuracy as

$$\frac{L_1}{L_2} = \left(\frac{P_2}{P_1} \right)^b \qquad (2)$$

The exponent, b, varies for different manufacturers. The majority of bearing manufacturers (McGill, SKF, MRC, Norma-Hoffman, Fafnir, and others) use $b = 3.0$. Notable exceptions are New Departure, which uses $b = 4.0$, and Timken ($b = 3.33$).

There is a growing trend among bearing manufacturers to adopt a standard method of rating bearing capacities. For this purpose, the concept "specific dynamic capacity" (sometimes called "basic dynamic capacity" or "specific capacity") was introduced. By definition, the specific dynamic capacity, C, is the radial load in pounds that will give the bearing a minimum life of 1 million revolutions of inner-ring rotation. This corresponds to a life of 500 hours at 33⅓ rpm.

From the definition of C, using $L_1 = 1.0$ million revolutions and $b = 3.0$, Equation 2 can be transformed into

$$L_n = \left(\frac{C}{P} \right)^3 \qquad (3.1)$$

$$\frac{C}{P} = \sqrt[3]{L_n} \qquad (3.2)$$

This equation is called the "classic-life formula."

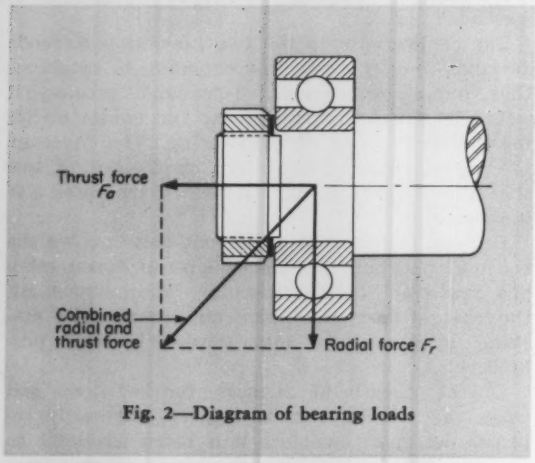


Fig. 2—Diagram of bearing loads

Table 2—Typical Specific Dynamic-Capacity

Basic Bearing Number	Bore Diameter (mm)	Bore Diameter (in.)	Ball Bearings — Single-Row Deep-Groove — Extra Light	Single-Row Deep-Groove — Light	Single-Row Deep-Groove — Medium	Double-Row Deep-Groove — Light	Double-Row Deep-Groove — Medium	Self-Aligning — Light	Self-Aligning — Medium
00	10	0.3937	790	805	1,400	1,240	.....	930	.....
01	12	0.4724	880	1,170	1,680	1,830	.....	945	1,620
02	15	0.5906	970	1,320	1,960	2,030	.....	1,270	1,740
03	17	0.6693	1,040	1,650	2,330	2,550	3,650	1,340	2,130
04	20	0.7874	1,620	2,210	2,750	3,400	4,300	1,690	2,140
05	25	0.9843	1,740	2,420	3,650	3,700	5,650	2,070	3,100
06	30	1.1811	2,280	3,350	4,850	5,150	7,500	2,700	3,700
07	35	1.3780	2,750	4,450	5,750	6,750	8,850	2,700	4,400
08	40	1.5748	2,900	5,050	7,050	7,650	10,800	3,300	5,100
09	45	1.7717	3,600	5,650	9,100	8,600	14,100	3,750	6,550
10	50	1.9685	3,750	6,050	10,700	9,200	16,500	3,900	7,450
11	55	2.1654	4,850	7,450	12,400	11,400	19,000	4,600	8,850
12	60	2.3622	5,050	9,050	14,100	13,700	21,800	5,200	10,000
13	65	2.5591	5,250	9,900	16,000	15,000	24,700	5,350	10,800
14	70	2.7559	6,550	10,700	18,000	16,300	27,500	5,950	12,800
15	75	2.9528	6,800	11,400	19,600	17,300	30,000	6,700	13,700
16	80	3.1496	8,200	12,500	21,300	19,000	32,500	6,900	15,200
17	85	3.3465	8,550	14,400	22,900	20,100	33,000	8,500	16,900
18	90	3.5433	10,000	16,600	24,700	23,300	35,500	9,800	20,100
19	95	3.7402	10,500	18,800	26,500	28,500	.....	.....	22,600
20	100	3.9370	10,400	21,100	30,000	32,000	.....	11,900	24,500
21	105	4.1339	12,500	23,000	32,000	30,000	.....	.....	25,500
22	110	4.3307	14,100	24,900	35,500	31,500	.....	15,200	28,500
24	120	4.7244	14,700	25,000	36,000	.....	.....	.....	.....
26	130	5.1181	18,300	27,000	39,500	.....	.....	.....	.....
28	140	5.5118	18,900	28,500	43,500	.....	.....	.....	.....
30	150	5.9055	21,700	30,500	47,500	.....	.....	.....	.....
32	160	6.2992	.....	32,000	48,000	.....	.....	.....	.....
34	170	6.6929	.....	36,500	54,000	.....	.....	.....	.....
36	180	7.0866	.....	39,000	61,000	.....	.....	.....	.....
38	190	7.4803	.....	.....	.....	.....	.....	.....	.....
40	200	7.8740	.....	.....	.....	.....	.....	.....	.....
44	220	8.6614	.....	.....	.....	.....	.....	.....	.....

Courtesy SKF Industries Inc.

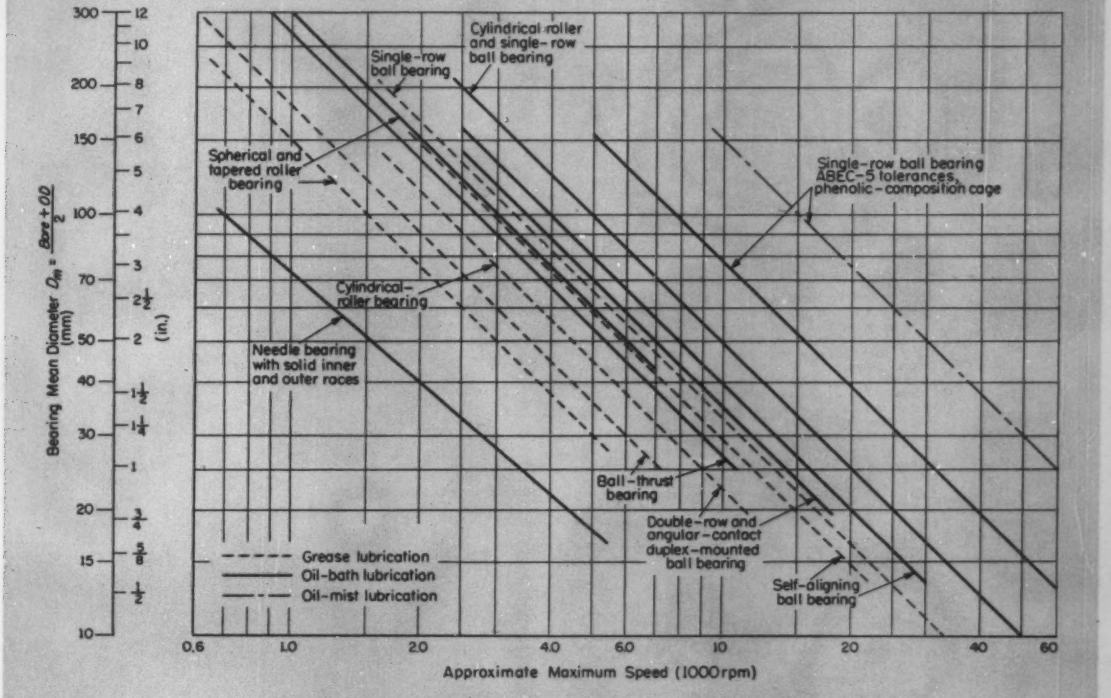
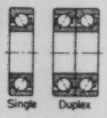
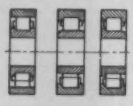
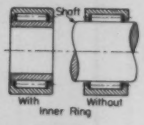
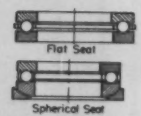
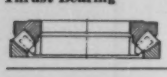


Fig. 3—Approximate recommended speed limits for ball and roller bearings. Values given are based upon Class 1 tolerances and standard cages except for high-speed, single-row ball bearings with phenolic-composition cages.

Values for Ball and Roller Bearings

Angular Contact — Light	Angular Contact — Medium	Ball Thrust	Spherical-Roller Bearings — Light	Spherical-Roller Bearings — Medium	Cylindrical-Roller Bearings — Light	Cylindrical-Roller Bearings — Medium	Basic Bearing Number	Bore Diameter (mm)	Bore Diameter (in.)
.....	.....	.....	.....	.....	.....	.....	00	10	0.3937
.....	.....	.....	.....	.....	.....	.....	01	12	0.4724
.....	.....	.....	.....	.....	.....	.....	02	15	0.5906
.....	.....	.....	.....	.....	.....	.....	03	17	0.6693
.....	.....	.....	.....	.....	.....	.....	04	20	0.7874
2,550	4,200	.....	.....	.....	2,450	5,200	05	25	0.9843
3,550	5,350	.....	.....	.....	4,050	6,800	06	30	1.1811
4,650	6,300	3,200	.....	.....	5,850	8,800	07	35	1.3780
5,550	7,750	4,300	.....	21,000	7,650	10,400	08	40	1.5748
6,200	10,100	4,550	.....	25,300	8,000	14,300	09	45	1.7717
6,450	11,800	4,900	.....	32,100	8,300	17,000	10	50	1.9685
7,950	13,600	6,000	.....	36,200	10,200	20,800	11	55	2.1654
9,650	15,500	7,100	.....	43,900	12,500	23,200	12	60	2.3622
11,000	17,600	7,350	.....	46,700	14,600	26,000	13	65	2.5591
11,900	19,800	7,650	.....	54,800	14,600	30,500	14	70	2.7559
12,300	21,500	8,150	.....	63,500	18,000	36,500	15	75	2.9528
13,900	23,300	8,300	32,900	68,700	19,600	36,500	16	80	3.1496
15,500	25,000	8,650	37,900	74,200	22,400	44,000	17	85	3.3465
18,400	27,000	11,000	44,300	87,500	28,500	47,500	18	90	3.5433
19,800	29,000	.....	51,400	94,200	31,500	54,000	19	95	3.7402
22,200	34,000	15,300	57,500	111,000	34,500	63,000	20	100	3.9370
.....	.....	.....	.....	.....	.....	.....	21	105	4.1339
26,000	40,000	16,300	74,800	132,000	46,500	81,500	22	110	4.3307
29,500	.....	17,000	86,500	153,000	50,000	98,000	24	120	4.7244
33,000	49,000	19,300	110,000	176,000	.....	116,000	26	130	5.1181
35,000	.....	20,000	113,000	202,000	.....	129,000	28	140	5.5118
40,000	58,000	.....	136,000	225,000	.....	140,000	30	150	5.9055
42,500	.....	.....	157,000	251,000	.....	.....	32	160	6.2992
43,500	.....	.....	177,000	280,000	.....	.....	34	170	6.6929
.....	.....	.....	186,000	313,000	.....	.....	36	180	7.0866
.....	.....	.....	203,000	342,000	.....	.....	38	190	7.4803
.....	.....	.....	229,000	369,000	.....	.....	40	200	7.8740
.....	.....	.....	278,000	.....	.....	.....	44	220	8.6614

Table 3—Popular Ball and Roller-Bearing Types

Bearing Type	Characteristics	Principal Applications	Approximate Equivalent-Load Equation: Inner-Ring Rotation	Approximate Equivalent-Load Equation: Outer-Ring Rotation
Single-Row Deep-Groove Ball Bearing	Most commonly used general-purpose ball bearing; can sustain radial load and considerable thrust load in either direction at high speeds. Is available with built-in seals or shields to exclude dirt and retain lubricant, or snap rings to reduce assembly and housing costs.	Machines of all types. Very small sizes often used in instrumentation.	$P=F_r+F_a$	$P=1.2F_r+F_a$
Single-Row, Filling-Notch Ball Bearing	Because of filling notch (loading groove), larger number of balls can be inserted than in deep-groove bearing of same size and has about 25 per cent higher radial capacity. Has very little thrust capacity. Recommended for radial loads only or small thrust loads in combination with radial loads.	General purpose applications with heavy radial load.	$P=F_r$ Note: F_a must be less than $F_r/4$	$P=1.2F_r$
Angular-Contact Single-Row Ball Bearing 	High shoulders provide for heavy thrust loads in one direction or radial load in combination with thrust load. At very high speeds, this bearing is preferred to ball-thrust bearings, even for pure-thrust loads. When mounted singly unopposed or in tandem, constant axial load in one direction is required. Otherwise, use opposed mounting in pairs or duplex bearings (back-to-back or face-to-face) to absorb thrust loads in either direction. Increased axial and radial rigidity is obtained by preloading.	High-speed machine tools, grinding spindles, automotive front-wheel bearings, worm drives.	Singly Unopposed: $F_a>F_r$ $P=0.3F_r+F_a$ Tandem Mounted: $F_a>F_r$ $P=F_r+0.6F_a$ Duplex Mounted: $F_a<1.4F_r$ $P=F_r+0.5F_a$ Duplex Mounted: $F_a>1.4F_r$ $P=0.3F_r+F_a$	$P=1.2F_r+0.3F_a$ $P=1.2F_r+F_a$ $P=1.2F_r+0.5F_a$ $P=0.36F_r+F_a$
Double-Row Ball Bearing	Available either as angular-contact or as deep-groove bearing. Both types have grooves positioned for outwardly converging contact angle similar to back-to-back duplex bearing. Has high axial and radial rigidity, substantial thrust capacity in either direction and high radial capacity. Requires very accurate alignment of housing and shaft.	Shafts for worm, spiral, bevel and helical gears, idler pulleys, live centers.	$P=F_r+F_a$	$P=1.2F_r+F_a$
Self-Aligning Ball Bearing	Two rows of balls roll on spherical surface of outer ring. Supports radial loads and moderate thrust loads in either direction at high speeds. Can sustain angular misalignment up to 3 deg without detriment, while running. Used where errors in mounting, distortion of housing, large angular shaft deflection, etc., are unavoidable. Cannot resist bending loads.	Woodworking and agricultural machinery, line shafts, long transmission shafts, pillow blocks.	$P=F_r+3F_a$	$P=F_r+3F_a$
Spherical-Roller Bearing	Self-aligning with barrel-shaped rollers and spherical raceway in outer ring. Carries heavy radial loads and heavy thrust loads in either direction. Considerable capacity to absorb shock loads. Popular in larger sizes.	Heavy machinery, rolling mills, stone crushers, printing presses, heavy-duty pillow blocks, railroad journals, drive shafts on ships.	$P=F_r+3F_a$	$P=1.2F_r+3F_a$
Cylindrical-Roller Bearing 	Very high radial capacity and suitable for high speeds. Available with guide flanges on outer, inner, or both rings. With flanges on one ring only, some free axial movement of shaft is permissible. With flanges on both rings, only small locating thrust loads can be accepted. Is not recommended for other thrust loads because of high side friction. Requires very accurate alignment of housing and shaft.	Machine-tool spindles, transmission shafts, gas turbines, aircraft engines.	$P=F_r$	$P=1.2F_r$
Needle Bearing 	For small radial space between housing and shaft. Sometimes inner or outer race is omitted and needle rollers run directly on hardened shaft or housing bore. Requires very accurate alignment of housing and shaft. Higher internal friction, lower speed limits, and greater diametral looseness than ball bearings. Usually has no cage.	Crankpins, wristpins, rocker arms, universal joints, cam rollers, compressors, aircraft controls.	$P=F_r$ No thrust load permissible	$P=1.1F_r$
Tapered-Roller Bearing	High axial and radial rigidity and heavy load-carrying capacity. Mounted opposed in pairs similar to angular-contact ball bearings. Accurate adjustment of internal clearance possible. Requires accurate alignment of housing and shaft, and skillful assembly.	Automobiles, heavy machine tools, railroad cars, steel-mill equipment, worm drives.	See manufacturer's catalog	
Ball Thrust Bearing 	For heavy thrust loads in one direction only, where minimum axial deflection is desired. Because of centrifugal forces, not recommended for high speeds and light loads. Radial load must be carried by other bearings. Flat seats provide accurate axial location; spherical seat is used when slight angular misalignment of shaft is present.	Machine tools, crane hooks, vertical rotating members.	$P=F_a$ No radial load permissible	
Spherical-Roller Thrust Bearing 	Can carry heavy thrust loads, is self-aligning, can operate at high speeds and accept slight radial loads when combined with thrust load.	Turntables, large crane hooks, water turbines, ship-screw thrust bearing, heavy pumps.	F_a must be $>1.5F_r$ $P=2F_r+F_a$ At high speeds, F_a must be $>2F_r$	

It has been incorporated into the standards established by the Anti-Friction Bearing Manufacturers Association, and is also used in many European countries.

The life formula can be readily used in cases where the speed is not constant, but where the total number of revolutions is significant. In vehicles, for example, the number of revolutions can be easily related to the number of miles traveled. As any motorist knows, the intervals of wheel-bearing replacement or relubrication are measured in terms of miles traveled, regardless of the speed and number of hours. Equation 3.2 is especially convenient because it readily establishes the ratio between the specific dynamic capacity and the permissible load. For example, if the expected minimum life is 8 million revolutions, then $L_n^{1/3} = 8^{1/3} = 2$, and the required specific capacity has to be twice the applied load.

Specific dynamic capacity values for bearings of one manufacturer are given in Table 2. Interchangeable bearings by different manufacturers vary in internal construction, but the values in Table 2 are representative of the capacity and life expectancy of typical bearings. This table can be used, at least, as a guide for preliminary estimates. After the load, speed, desired life, and bearing type are decided upon, the value of C can be found using Equations 1 and 3.1. The corresponding bearing size is then selected from Table 2. If the calculated C value falls between two values on the table, the next larger size is selected.

Equivalent Load

Under ordinary running conditions, a bearing very seldom carries only pure radial load or pure thrust load. In most cases, the load is a combination of both. Before selecting a bearing, these loads should be determined as accurately as possible. Calculations should take into account the torque transmitted by the shaft, weight of supported components, centrifugal and inertia effects, etc. In most radial bearings, the endurance of the inner ring against fatigue is lower than that of the outer ring. Therefore, their load conditions are different.

To extend the use of the life formula to calculations involving thrust loads, simultaneous radial and thrust loads, and cases where the outer ring rotates relative to the load, the "equivalent load" must be established. By definition, the equivalent load is that constant, stationary radial load which, if applied to a rotating inner ring, would give the same life as that which the bearing would attain under actual conditions of load and rotation.

Calculation of the equivalent load, P depends on the type of bearing, its internal construction, and the ratio between the axial and radial-load components. Some common bearing types, their characteristics, and approximate equations for estimating the equivalent load are given in Table 3. These equations are mostly on the safe side and can be used for comparison of the life of various bearings. For less approximate calculations of equivalent loads, the manufacturer's catalog has to be consulted for each individual bearing series.

The load-calculation methods given imply ideal conditions of steady, constant loading. In actual practice, the equivalent load has to be multiplied by an application factor to take into account conditions of shock, vibration and severity of service. This factor may vary from 1 for light rotating machines, free from shock, to 3 for reciprocating machines with heavy impact. If the load varies gradually and uniformly from minimum to maximum at constant speed, the effective equivalent

Table 4—Approximate Friction Coefficients

Bearing Type	Coefficient μ
Self-aligning ball bearing	0.0010
Cylindrical roller bearing	0.0011
Thrust ball bearing	0.0013
Single-row ball bearing	0.0015
Tapered-roller bearing	0.0018
Spherical-roller bearing	0.0018
Needle bearing	0.0045

From Ref. 5

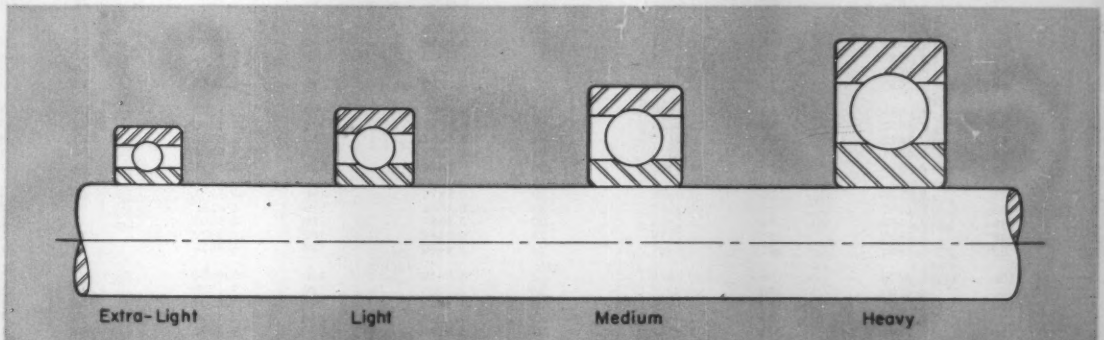


Fig. 4—Relative proportions of bearings of the same bore size

load can be found by

$$P_{eff} = P_{min} + \frac{2(P_{max} - P_{min})}{3}$$

In oscillating bearings, the life can generally be calculated on the basis of the oscillations per minute being equal to the revolutions per minute except for small angles of oscillation (less than 60 deg). In these cases, the danger of fretting corrosion exists, and application factors must be applied, governed by judgment and experience.

Static Capacity

The life formula is very useful for ordinary speeds and loads. However, it should not be used indiscriminately. For very low values of L_n, or when the bearing is at rest, factors other than fatigue life demand primary consideration. These factors are permanent deformation of the stressed surfaces or the danger of fracture of the load-carrying bearing components. The limiting load that a bearing can carry at rest without excessive permanent deformation is called the "basic static capacity" or briefly, "static capacity."

In most commercial bearings, the approximate ratio between the values of basic static capacity and specific dynamic capacity varies from 1:2 for the smaller bearing sizes (10 mm bore or less), to 1:1 for large sizes (100 mm bore approximate) with 1.25:1 for very large sizes (200 mm bore and larger). These ratios do not apply to pure thrust bearings, which have a basic static capacity considerably larger than the dynamic capacity.

In applications where the bearing is used only intermittently and at low speeds, it is safe practice to assume L_n = 1 million revolutions and the load ratio, C/P = 1.0. However, in some special cases when increased bearing friction and very short life are not objectionable, the load can be considerably increased above the value of C. Such instances demand special analysis, taking into account the race thickness, size of rolling elements, etc. In no case, however, should the applied load exceed four times the specific static capacity.

Friction and Limiting Speeds

Despite the often-used expression "antifriction bearings," some friction is always present in ball and roller bearings. This friction is due to sliding between the cage and the rolling elements, viscosity of the lubricant, possible inaccuracies in the ground raceways, and rolling friction.

So far, it has been impossible to calculate exactly the values of the frictional torque. Also, the frictional coefficient may vary considerably with load, speed and lubrication. For normal operating conditions and favorable lubrication, the values for the friction coefficient (based on experience) given in Table 4, can be used in rough calculations.

The friction coefficients in Table 4 refer to the bearing bore and do not apply to freshly installed bearings, which have higher friction. Also, the friction of external or built-in seals should not be neglected, since it is often considerably higher than the bearing friction. The bearing frictional torque can be calculated by

$$T = \mu P \left(\frac{B}{2} \right) \qquad (4)$$

Bearing friction causes an increase in temperature. At very high speeds, this temperature rise may exceed the permissible limit. At high speeds, the design and material of the cage and the bear-

Table 5—SAE and International Standard

SAE Bearing Number	Bore Diam (mm)	Bore Diam (in.)	Extra-Light Series: Outside Diam (mm)	Extra-Light Series: Outside Diam (in.)	Extra-Light Series: Width (mm)	Extra-Light Series: Width (in.)	Light (200) Series: Outside Diam (mm)	Light (200) Series: Outside Diam (in.)	Light (200) Series: Width (mm)	Light (200) Series: Width (in.)
00	10	0.3937	26	1.0236	8	0.3150	30	1.1811	9	0.3543
01	12	0.4724	28	1.1024	8	0.3150	32	1.2598	10	0.3937
02	15	0.5906	32	1.2598	9	0.3543	35	1.3780	11	0.4331
03	17	0.6693	35	1.3780	10	0.3937	40	1.5748	12	0.4724
04	20	0.7874	42	1.6535	12	0.4724	47	1.8504	14	0.5512
05	25	0.9843	47	1.8504	12	0.4724	52	2.0472	15	0.5906
06	30	1.1811	55	2.1654	13	0.5118	62	2.4409	16	0.6299
07	35	1.3780	62	2.4409	14	0.5512	72	2.8346	17	0.6693
08	40	1.5748	68	2.6772	15	0.5906	80	3.1496	18	0.7087
09	45	1.7717	75	2.9528	16	0.6299	85	3.3465	19	0.7480
10	50	1.9685	80	3.1496	16	0.6299	90	3.5433	20	0.7874
11	55	2.1654	90	3.5433	18	0.7087	100	3.9370	21	0.8268
12	60	2.3622	95	3.7402	18	0.7087	110	4.3307	22	0.8661
13	65	2.5591	100	3.9370	18	0.7087	120	4.7244	23	0.9055
14	70	2.7559	110	4.3307	20	0.7874	125	4.9213	24	0.9449
15	75	2.9528	115	4.5276	20	0.7874	130	5.1181	25	0.9843
16	80	3.1496	125	4.9213	22	0.8661	140	5.5118	26	1.0236
17	85	3.3465	130	5.1181	22	0.8661	150	5.9055	28	1.1024
18	90	3.5433	140	5.5118	24	0.9449	160	6.2992	30	1.1811
19	95	3.7402	145	5.7087	24	0.9449	170	6.6929	32	1.2598
20	100	3.9370	150	5.9055	24	0.9449	180	7.0866	34	1.3386
21	105	4.1339	160	6.2992	26	1.0236	190	7.4803	36	1.4173
22	110	4.3307	170	6.6929	28	1.1024	200	7.8740	38	1.4961
24	120	4.7244	180	7.0866	28	1.1024	215	8.4646	40	1.5748
26	130	5.1181	200	7.8740	33	1.2992	230	9.0551	40	1.5748
28	140	5.5118	210	8.2677	33	1.2992	250	9.8425	42	1.6535
30	150	5.9055	225	8.8583	35	1.3780	270	10.6299	45	1.7717
32	160	6.2992	240	9.4488	38	1.4961	290	11.4173	48	1.8898
34	170	6.6929	260	10.2362	42	1.6535	310	12.2047	52	2.0472
36	180	7.0866	280	11.0236	46	1.8110	320	12.5984	52	2.0472

ing tolerances play an important part.

Very often, the "*dN*-number" of a bearing type is used to indicate the maximum permissible speed. This number is the product of the bearing bore in millimeters and the maximum speed in revolutions per minute. According to this formula, for example, a *dN*-number of 200,000 means that a bearing with a 50-mm bore diam would have a maximum permissible speed of 4000 rpm. However, this rule does not take into account the different bearing series—extra light, light, medium, and heavy. For identical bore diameters, various series have different outside diameters and different pitch-line diameters of the rolling elements. The rubbing velocity between cage and balls is higher for a ball bearing in the medium series than for one in the extra-light series with the same bore diameter, turning at the same rpm. Therefore, the maximum permissible speeds cannot be the same if other conditions are equal.

The bearing mean diameter, $D_m = (B + D)/2$, is a better denominator to determine the limiting speed. It takes into account the differences between bearing series, and closely approaches the pitch-line diameter of the balls or rollers for most bearing types. Approximate maximum speeds for commonly used bearing types are given, Fig. 3. Whenever an application requires speeds approaching or exceeding the indicated limits, the manufacturer should be consulted for special recommendations.

Bearing Series

Most ball and roller-bearing types are made to standardized dimensions and tolerances of bore, outside diameter, and width. These dimensions are, in most cases, expressed in millimeters and conform to international standards. Some manufacturers supply inch-series ball bearings in addition to those in millimeter dimensions. Needle bearings and tapered-roller bearings, however, are furnished mostly in inch dimensions. Bore diameter of the bearing is indicated by the last two digits of the bearing number. These digits are sometimes called the basic bearing number or SAE bearing number. A bearing bore of 10 mm is indicated by the digits 00, 12 mm by 01, 15 mm by 02, and 17 mm by 03. For 20-mm bores and larger, the bore diameter in millimeters is five times the basic bearing number. For example, if the last two digits of a particular bearing number are 12, the bore diameter is 60 mm.

For each standard bore size, ball and roller-bearing types are made in different series, or proportions, of width and outside diameter, Fig. 4. These are known as extra light, light, medium, and heavy series. Table 5 lists the standardized external dimensions for all four of the ball and roller-bearing series. Some popular bearing types are furnished in one, two, three, or all four of these series.

Extra-light series, as the name implies, have the smallest outside diameter for a given standard bore size. This series is suitable for applications where large shaft diameters are desired for added rigidity, but where the housing diameter has to be kept within certain limits. This is often the case with relatively long or overhanging shafts, where the load is applied at a considerable distance from the bearing. In many such cases, deflection is the important consideration. The extra-light series is also often used on hollow and tubular shafts, where large bore sizes are required as compared

External Dimensions for Ball and Roller Bearings

Medium (300) Series				Heavy (400) Series				SAE Bearing Number
Outside Diam (mm)	Outside Diam (in.)	Width (mm)	Width (in.)	Outside Diam (mm)	Outside Diam (in.)	Width (mm)	Width (in.)	
35	1.3780	11	0.4331	..	.....	..	.....	00
37	1.4567	12	0.4724	..	.....	..	.....	01
42	1.6535	13	0.5118	..	.....	..	.....	02
47	1.8504	14	0.5512	62	2.4409	17	0.6693	03
52	2.0472	15	0.5906	72	2.8346	19	0.7480	04
62	2.4409	17	0.6693	80	3.1496	21	0.8268	05
72	2.8346	19	0.7480	90	3.5433	23	0.9055	06
80	3.1496	21	0.8268	100	3.9370	25	0.9843	07
90	3.5433	23	0.9055	110	4.3307	27	1.0630	08
100	3.9370	25	0.9843	120	4.7244	29	1.1417	09
110	4.3307	27	1.0630	130	5.1181	31	1.2205	10
120	4.7244	29	1.1417	140	5.5118	33	1.2992	11
130	5.1181	31	1.2205	150	5.9055	35	1.3780	12
140	5.5118	33	1.2992	160	6.2992	37	1.4567	13
150	5.9055	35	1.3780	180	7.0866	42	1.6535	14
160	6.2992	37	1.4567	190	7.4803	45	1.7717	15
170	6.6929	39	1.5354	200	7.8740	48	1.8898	16
180	7.0866	41	1.6142	210	8.2677	52	2.0472	17
190	7.4803	43	1.6929	225	8.8583	54	2.1260	18
200	7.8740	45	1.7717	250	9.8425	55	2.1654	19
215	8.4646	47	1.8504	265	10.4331	60	2.3622	20
225	8.8583	49	1.9291	290	11.4173	65	2.5591	21
240	9.4488	50	1.9685	320	12.5984	70	2.7559	22
260	10.2362	55	2.1654	..	.....	..	.....	24
280	11.0236	58	2.2835	..	.....	..	.....	26
300	11.8110	62	2.4409	..	.....	..	.....	28
320	12.5984	65	2.5591	..	.....	..	.....	30
340	13.3858	68	2.6772	..	.....	..	.....	32
360	14.1732	72	2.8346	..	.....	..	.....	34
380	14.9606	75	2.9528	..	.....	..	.....	36

to the load carried.

Light-series bearings are widely used for normal and moderately heavy loads, and are usually the first choice for average bearing applications.

Medium-series bearings provide 30 to 40 per cent larger capacity than the light-series bearings of the same bore size. They are used for relatively heavy loads and applications requiring very long bearing life. These bearings are proportionately wider and of larger outside diameter than the light series and require more housing space.

Heavy-series bearings have a still larger cross section than the medium-series bearings. The added capacity of these bearings is seldom commensurate with the extra cost and space requirements. Also, specially proportioned shafts are required. For these reasons, heavy-series bearings are less used than other series, and are manufactured only in a few types and bore sizes.

BIBLIOGRAPHY

1. Thomas Barish—"A Theoretical Derivation of Ball Bearing Ratings", ASME Annual Meeting, 1946.
2. W. Juergensmeyer—*Die Waelzlager,* Springer, Berlin, 1937.
3. W. Juergensmeyer and H. von Bezold—*Gestaltung von Waelzlagerungen,* Springer, Berlin, 1953.
4. Gustaf Lundberg and Arvid Palmgren—*Dynamic Capacity of Rolling Bearings,* Acta Polytechnica, Stockholm, 1948.
5. Arvid Palmgren—*Ball and Roller Bearing Engineering,* SKF Industries Inc., Philadelphia, 1945.
6. *New Departure Handbook, Vol. I and II,* New Departure, Bristol, Conn., 1951.
7. *SKF General Catalog and Engineering Data,* Catalog No. 350, 2nd ed., SKF Industries Inc., Philadelphia, 1956.
8. *Timken Engineering Journal,* Timken Roller Bearing Co., Canton, Ohio.
9. *AFBMA Standards,* Section 9, Antifriction Bearing Manufacturers Association, New York, 1950.

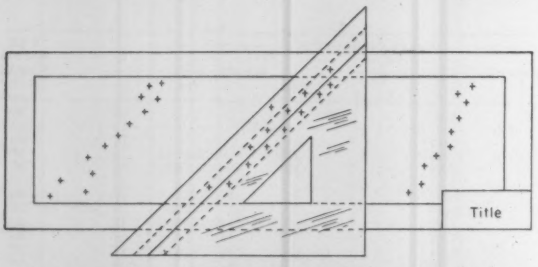
Earlier articles on ball bearing selection and application have appeared in the following issues of MACHINE DESIGN:

"Basic Ball Bearings" ..... February 23, 1956
"High-Performance Ball Bearings—Lubrication Systems" ..... September 20, 1956
"High-Performance Ball Bearings—Lubricant Selection" ..... October 18, 1956
"Ball Bearings for High Speeds" ..... November 15, 1956
"Needle Bearings" ..... November 28, 1957

Tips and Techniques

Estimating Distribution

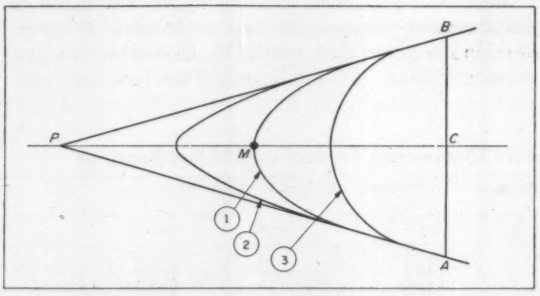
In analyzing plotted data, a triangle is a convenient tool to determine a "line of best fit" if a straight line has been marked on the underside.



If the data are consistently compared against a known distribution, lines indicating limits of distribution or standard deviations can also be placed next to the centerline.—ROBERT L. EBERHARDT, *Todd Shipyards Corp., Los Angeles Div., San Pedro, Calif.*

Which Conic Section?

Given a portion of a conic section, it is a simple matter to determine whether the section is a parabola, hyperbola or ellipse.



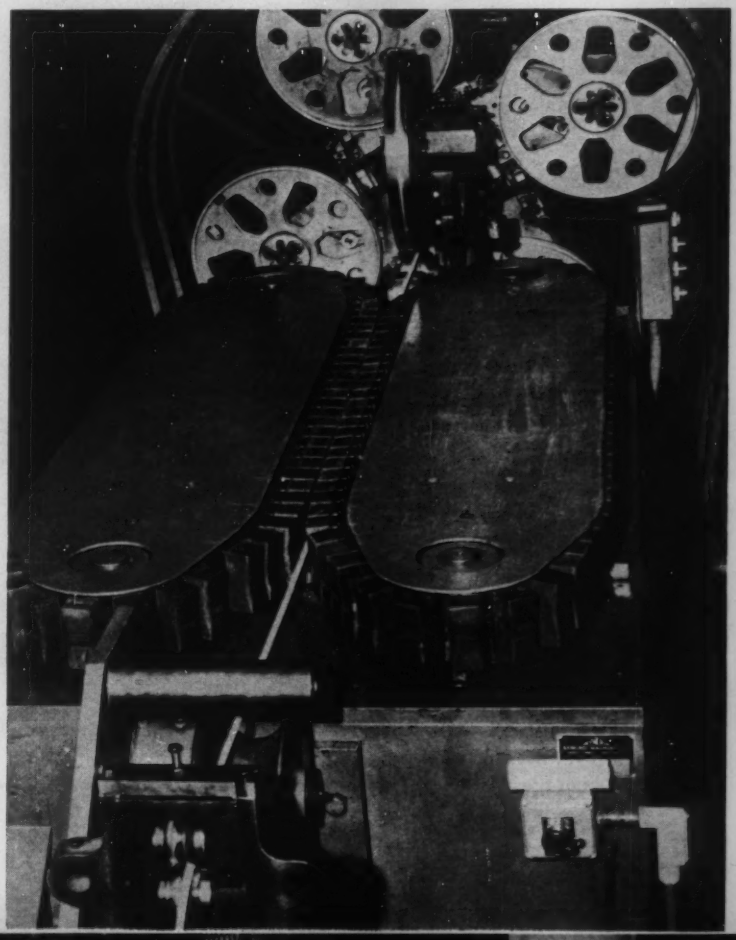
1. Draw any chord, *AB*, across the given section
2. Draw tangents to the curve at *A* and *B* to meet at *P*
3. Find the midpoint, *C*, of *AB* and draw *CP* to the intersection of the tangents
4. Find midpoint, *M*, of *PC*
5. **A parabola** will cross *PC* at the midpoint, *M;* (curve 1)
6. **A hyperbola** will cut line *PM;* (curve 2)
7. **An ellipse** will cut line *MC;* (curve 3)

—ARNE BENSON, *Sanders Associates Inc., Nashua, N. H.*

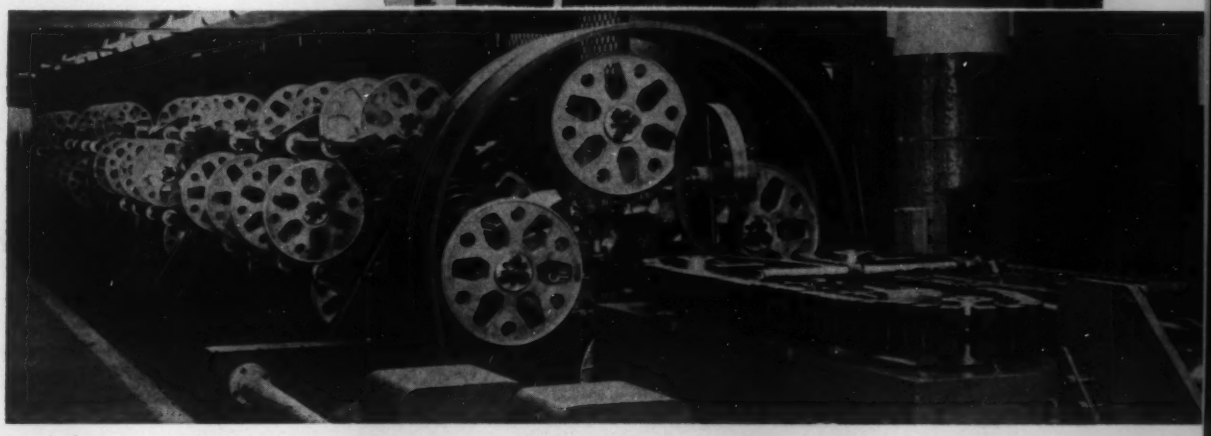
Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Crawler-Tractor Type Grippers Pull Paper-Covered Wire

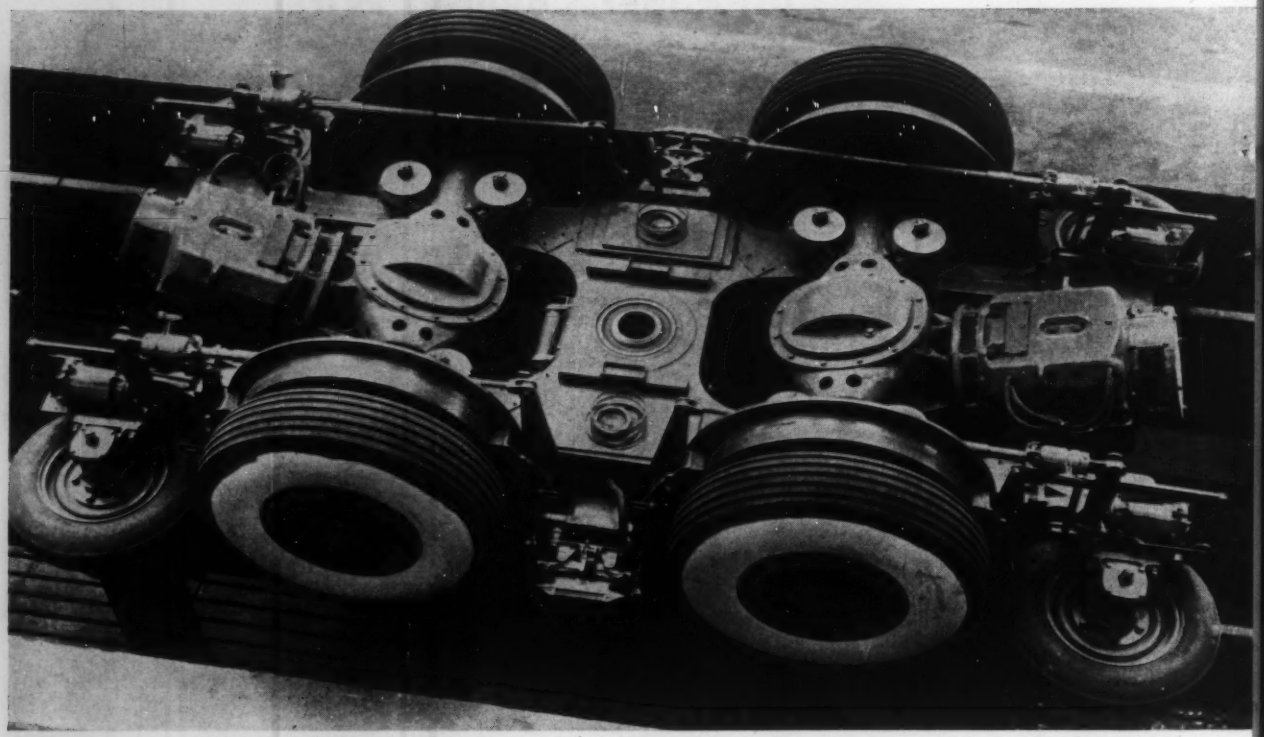
DUAL GRIPPING "BELTS" are used to pull out paper-insulated, high-voltage paper in a machine designed by the Syncro Machine Co., Perth Amboy, N. J. The multiple-tread belts made of neoprene protect the cable from damage or excessive bending. Length of traction contact between the cable and threads is 42 in. A pulling force of about 4000 lb can be produced. Neoprene treads of various densities are used depending on the type of cable being run.



AUTOMATIC WRAPPING of cable diameters from 1/4 to 3 1/2 in. is accomplished by the machine's 64 taping heads. This particular paper insulating machine is installed at the John A. Roebling's Sons Corp., Trenton, N. J.

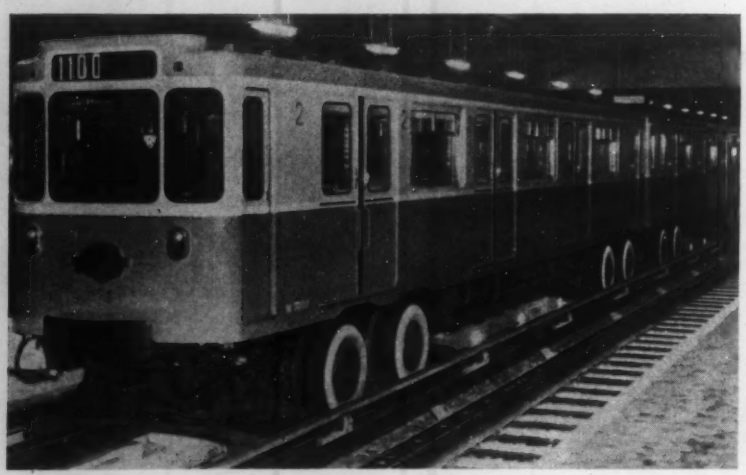


Rubber-Tired Subway Train



REDUCED NOISE AND VIBRATION are provided in a new electric subway train that runs on, and is guided by, pneumatic rubber tires. Used on trains on 14 lines operated by the Paris Subway and Surface Public Transport Authority, each train truck is designed with a total of eight rubber tires and four lightweight steel wheels.

Data and photos, courtesy Nelson Stud Welding Div., Gregory Industries Inc.

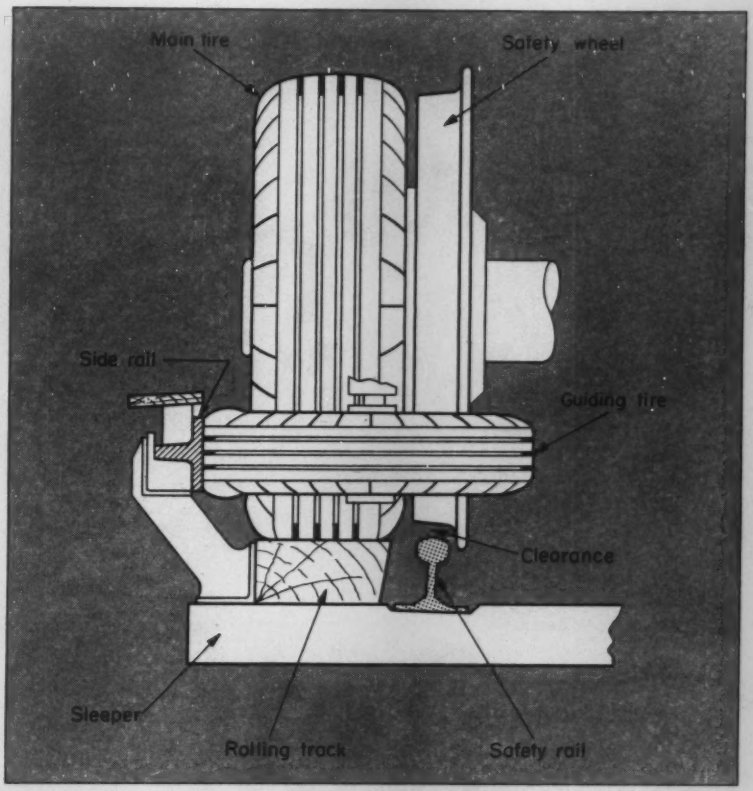


PASSENGER RIDING COMFORT and flexibility of operation are the main design advantages of this pneumatic-tired train set. Elasticity of the pneumatic tires and their good adhesion to the track permit following the surface of the streets closely in spite of heavy slopes.

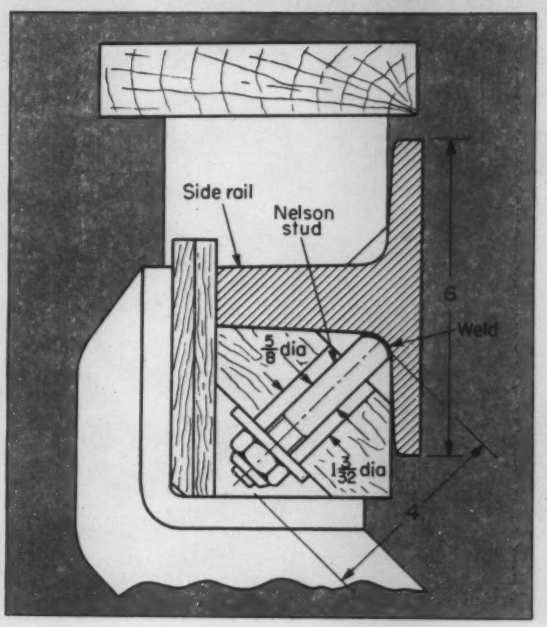
Designed to Run on Wooden Tracks

GUIDING ACTION for the trucks is provided by four pneumatic-tired horizontal wheels mounted on each truck. These wheels bear against T-shaped steel side rails. The four main tires on each truck roll on a wooden track made of red ironwood.

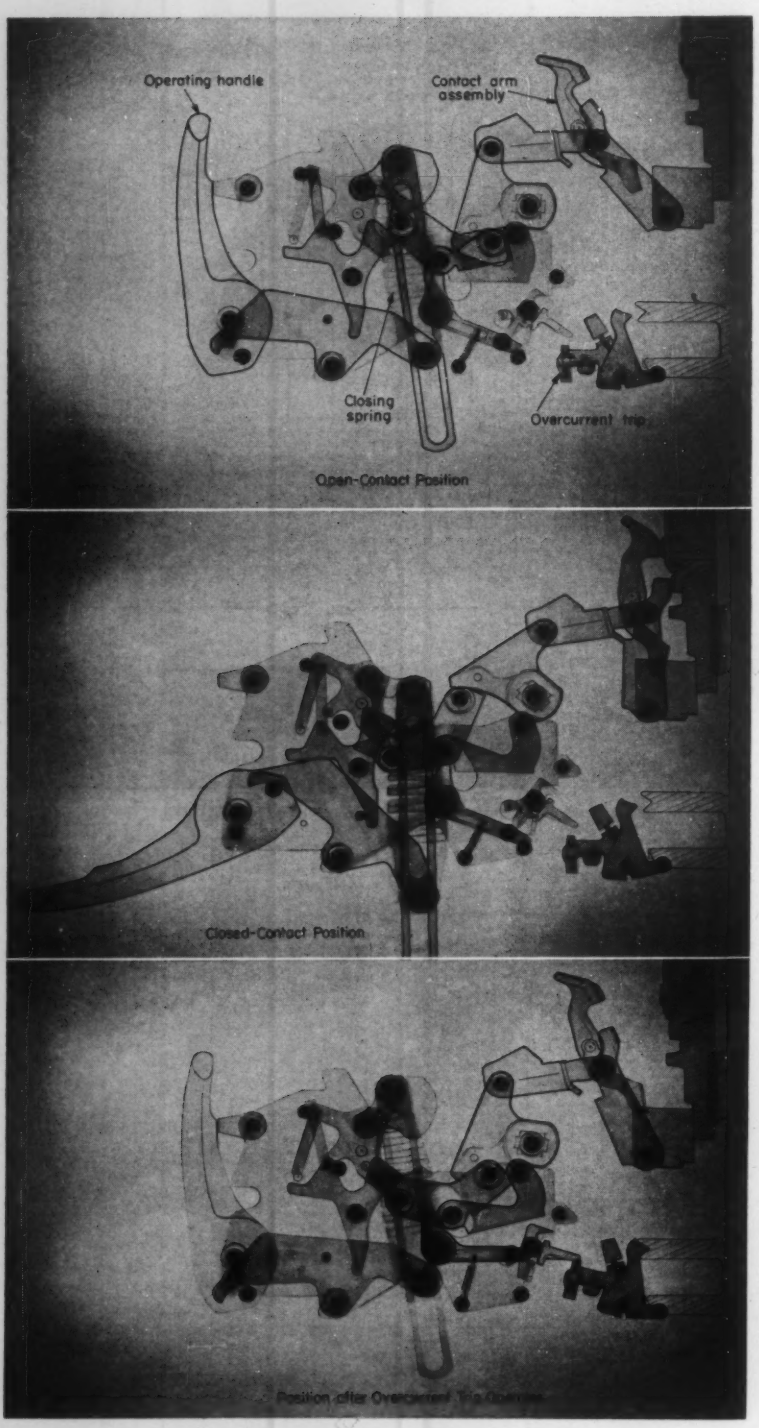
The steel safety wheels play a triple role in the design. First, they ensure guiding of the car at places where side rails are interrupted, such as at switches and crossings. Second, they roll on the rail and provide support in the event of a tire blowout. Third, they act as the drums for external brakes.



WELDED NELSON STUDS, fastened at a 45-deg angle, secure the T-shaped guide rails upon the insulating blocks. This mounting technique eliminates the need for both horizontal and vertical studs.



Springs in Manual Circuit Breaker

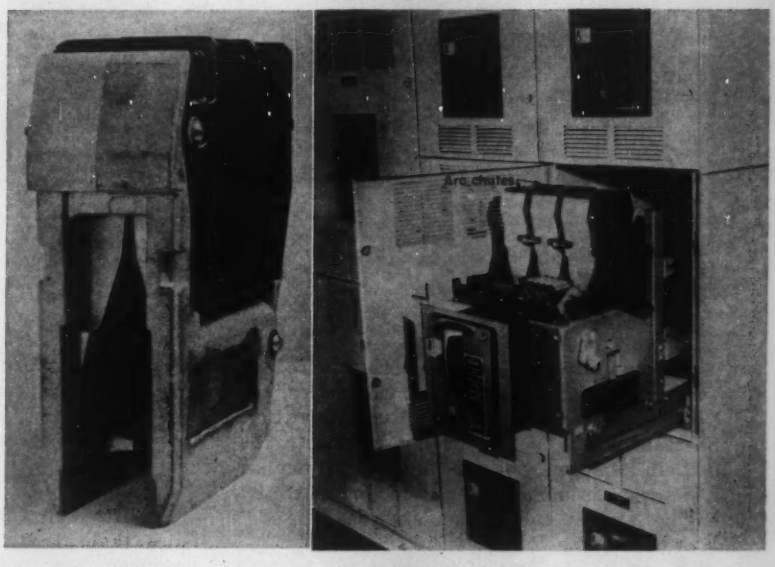


SNAP-ACTION CLOSING mechanism used in circuit-breaker design doesn't depend on the operator to provide proper contact-closing speed. The closing mechanism, which minimizes contact arcing, is incorporated in a new line of low-voltage, power-type circuit breakers developed by Switchgear Div., I-T-E Circuit Breaker Co. The spring-loaded unit is designed for manual or motor operation. It latches the breaker in a closed position and allows the breaker to trip when required.

PULL-DOWN HANDLE moved through first 90 per cent of travel extends a pair of helical springs in the closing mechanism. During the last 10 per cent of handle travel, the spring energy is released to close the contacts quickly and forcefully. After the operator lets go of the handle, it returns to its original position.

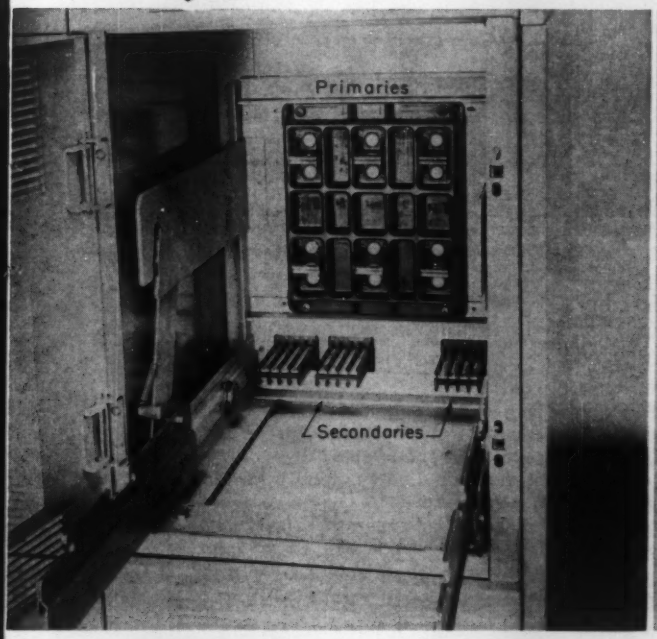
Automatically Control Closing Speed

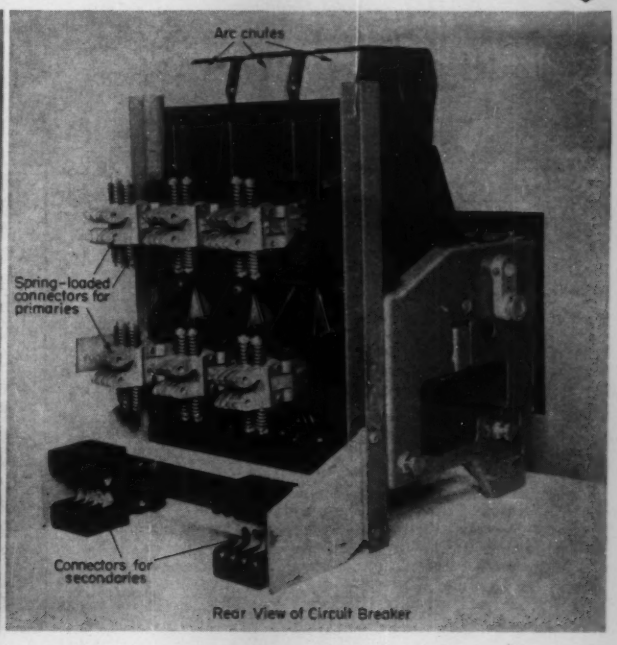
ARC FOLDBACK DESIGN used in circuit breaker cuts height of arc chute in half. The arc is directed upward, as in conventional designs, then back down by a baffle structure surrounding the top and sides of chute. The arc finally exhausts at sides from bottom of dark-colored baffle. Construction consists of asbestos-compound body, metal cooling plates and baffling made of a glass-polyester plastic composition.



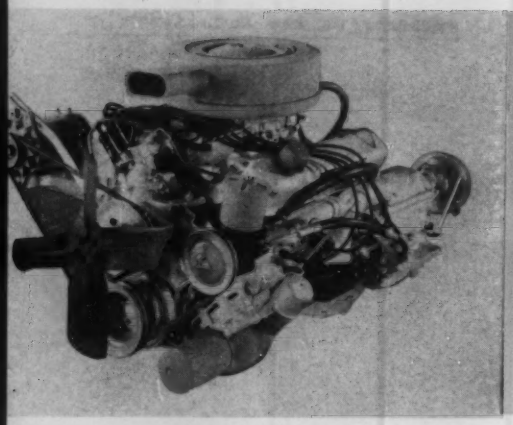
TELESCOPING TWO-STAGE track, in extended position, shows point where breakers can be removed by direct lift. The track is part of a cradle assembly which simplifies breaker change when increased capacity is needed. Breaker slides from compartment on a rail-and-wheel design setup.

SPRING-LOADED FINGERS in rear of breaker tightly grip primary blades in the main current-carrying primaries. The parallel-finger arrangement provides blow-on action. Each finger pair is held by a separate spring which is outside of the current path. Secondary connectors, also of blow-on design, for control circuits, are mounted at base of breaker well below main current-carrying contacts. Up to 32 secondary connectors can be provided.





Rear View of Circuit Breaker



Mechanics of Vehicles—13

By JAROSLAV J. TABOREK*
Development Engineer
Towmotor Corp.
Cleveland

BASIC limitations to vehicle performance, reviewed in Parts 9 and 10 of this series, are set by the maximum tractive force that can be transferred by the driving wheels to the ground. In the analysis of these performance limits, it was assumed that torque supplied by the engine always equaled or exceeded the demands of the driving wheels.

In this article, the first of two that will be presented treating the subject of vehicle performance prediction, general characteristics desired of a vehicle powerplant are introduced, and methods for correcting standard data to existing atmospheric conditions are reviewed. Also surveyed are the power losses in accessories and drive-system components.

*Now Research and Development Engineer, Phillips Petroleum Co., Bartlesville, Okla.

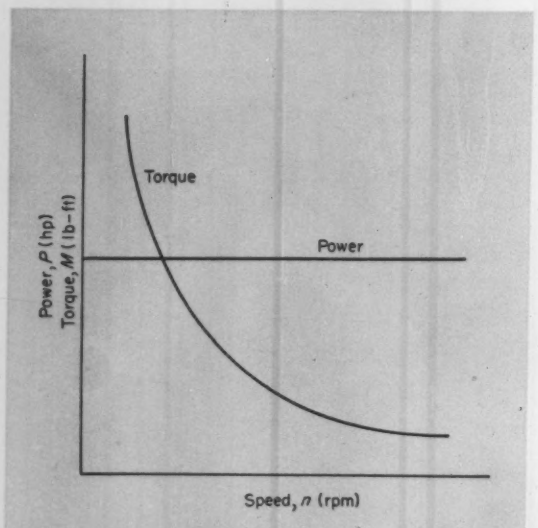


Fig. 68—Powerplant characteristics ideally suited for vehicle propulsion show constant power output over the entire speed range. This gives a hyperbolic torque curve and provides high tractive forces for vehicle acceleration at low road speeds.

Vehicle Powerplants: Performance characteristics that ideally suit a powerplant for vehicle propulsion are: 1. Constant power output throughout the usable speed range. 2. Torque that peaks in the low-speed range where traction demands for grade climbing and acceleration are high. Plotted against engine speed, the characteristic curves of such a powerplant have the form of a straight line for power output P and a hyperbola for the torque M, Fig. 68. The equation of the torque characteristic has the general form

$$M = \frac{5252\,P}{n}$$

Automotive powerplants in actual use have characteristics differing more or less from these ideal

Nomenclature

B	= Barometric pressure, in. Hg
B_o	= SAE standard barometric pressure (=29.92 in. Hg)
B_v	= Vapor pressure of air, in. Hg
c	= Number of cylinders
D	= Cylinder bore, in.
M	= Engine torque, lb-ft
n	= Speed, rpm
P	= Power delivered at output shaft, hp
p_b	= Brake mean effective pressure, psi
Q	= Volume output of pump, gpm
s	= Piston stroke, in.
T	= Absolute temperature, °R
T_o	= SAE standard air temperature (=520°R)
x	= Revolutions per power stroke (x = 2 for four-stroke cycle)
η	= Efficiency

Powerplant Characteristics

- propulsion requirements
- standard performance data
- accessory losses
- transmission characteristics

requirements. In following sections, the internal-combustion engine, which powers the majority of automotive vehicles is discussed in detail; other powerplant types are reviewed briefly for comparison.

STEAM ENGINES: The steam engine, which as a rule develops peak power output at very low speeds, has characteristics that come close to satisfying requirements of the ideal automotive powerplant, Fig. 69. Such an engine would eliminate the need for a speed-change transmission and could be directly coupled to the vehicle driving axle. Despite these excellent qualities, use of the steam engine is generally limited to railroad applications, and seldom is it seen on automotive vehicles. One reason for this is the time required to put the steam engine into operation; a second disadvantage is poor power-to-weight ratio. Both these qualities are of decisive importance in road vehicles.

ELECTRIC MOTORS: The series-wound electric motor also has power-torque characteristics which approach the ideal for vehicle propulsion. There are two applications where electric powerplants are used in vehicles:

1. In battery-operated vehicles, mostly of the industrial type, requiring high tractive forces at very low speeds. These are conditions for which the electric motor is best suited. The power source is a storage battery; capacity of the battery determines the operation time for which the vehicle is independent of its base. Use of battery-powered vehicles is limited to short-range applications where weight is not objectionable. Often, in fact, battery weight is an advantage, for example, in industrial tractors and lift trucks.

2. Trolley buses, which find use in city transportation systems, operate on alternating current supplied from an overhead wiring system. The excellent adaptability of the electric motor to high-torque acceleration demands makes it an ideal powerplant for bus service with characteristically frequent stops. The superiority of the electric motor over internal-combustion engine power is still unsurpassed in this respect.

INTERNAL-COMBUSTION ENGINE: Of all the possible power sources for propelling automotive vehicles, the internal-combustion engine has the most unfavorable power-torque characteristics, and can be used only in conjunction with a torque multiplying transmission. This is because of the inherent property of the engine to develop power in proportion to speed, giving torque-output characteristics unsuited for vehicle propulsion. Paradoxically, the internal combustion engine has nevertheless found the widest acceptance for automotive vehicles, due principally to its excellent

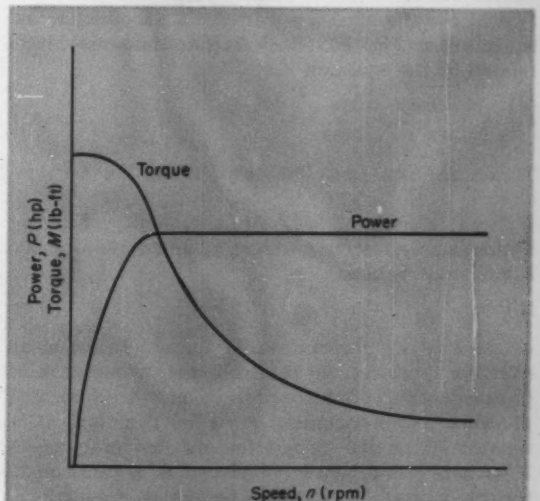


Fig. 69—Characteristics of the steam engine and the series-wound electric motor closely approximate the ideal for vehicle propulsion.

readiness for operation, high power-to-weight ratio, and wide availability of fuel.

Two different internal-combustion engine applications can be distinguished:

1. *Direct Drive:* In direct drive, which accounts for the majority of current applications, the engine is coupled through a transmission directly to the driving axle. The transmission can be mechanical (gear shift) or hydraulic (torque-converter type).

2. *Indirect Drive:* The internal combustion is merely the initial power source in the indirect-drive system; the actual driving is done by either electric or hydraulic systems.

The engine-electric drive combines the good operational properties of the combustion engine with the desirable power-torque characteristics of the electric motor. The relatively low efficiency of the combination, due to double transformation of power, is improved by running the engine at its economic optimum. Use of this type powerplant is limited at present to railroads and heavy duty industrial vehicle applications where advantages offered by the flexibility of the electric drive balance the increased cost and weight of the combination.

In the hydraulic-drive system, the engine drives a constant-displacement hydraulic pump which, in turn, supplies hydraulic fluid under pressure to a variable-displacement hydraulic motor coupled to the drive axle. Hydraulic-motor pressure and volume demands correspond to instantaneous driving conditions. Low efficiency of this combination is again justified by the excellent power-torque characteristics of the hydraulic-motor drive. The system is increasing in popularity for high-torque applications, where stepless speed regulation is essential.

Internal-Combustion Engine Characteristics: A typical power-torque diagram for a gasoline engine is shown in Fig. 70. Basic engine data are interrelated by the equation

$$P = \frac{p_b\, nDsc}{396{,}000\, x} = \frac{Mn}{5252} \qquad (261)$$

Terms in Equation 261 are defined in Nomenclature.

From Equation 261, proportionality between brake mean effective pressure p_b and engine torque M can be derived as

$$M = kp_b \qquad (262)$$

where k is the proportionality factor. Brake mean effective pressure is in itself not a measurable physical value, but is proportional to indicated pressure. Consequently, it is a function of a number of engine design factors and efficiencies. It is noted that power developed is a function of the product $p_b \times n$, while torque is proportional only to p_b.

The gasoline engine starts to run smoothly at a certain minimum or idle speed n_{min} and produces excess power at speeds above this point. Optimum combustion quality, and therefore maximum effective pressure, is reached at a medium engine speed where, as a result, maximum engine torque is developed. This point is designated in Fig. 70 as n_M. Power output at this rather low speed is also relatively low, which accounts for the poor adaptability of the combustion engine as a vehicle powerplant.

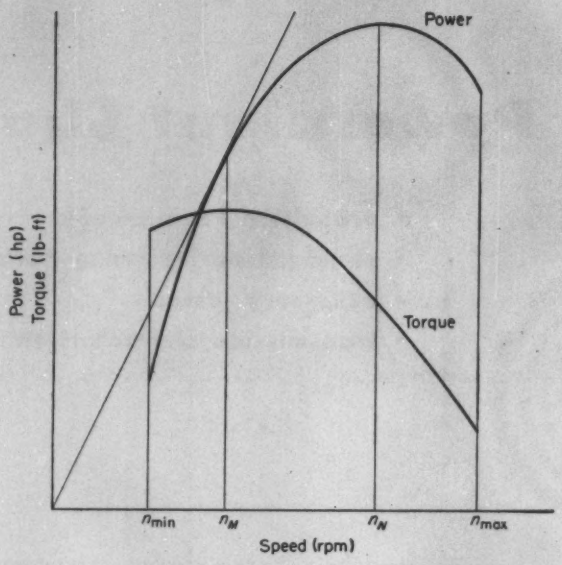


Fig. 70—Typical full-throttle characteristics of a gasoline engine. Maximum torque is given at speed n_M, which corresponds to the point of tangency of a line drawn from the origin to the power curve. Minimum speed, n_{min}, is engine idling speed; maximum torque is reached at relatively low power levels. Both of these characteristics account for the poor adaptability of the internal combustion engine for vehicle propulsion and point up the need for a change-gear transmission.

As speed increases further, brake mean effective pressure deteriorates due to the rapidly growing losses in the air-induction manifolds. Torque therefore starts to decline.

Power output is in nearly straight line proportion with speed up to the point of maximum torque. Beyond this point, the rate of power increase $\Delta P/\Delta n$ falls off until the maximum-power-output point is reached at n_N. The relative positions of n_N and n_M are often used as comparative measures of the quality and adaptability of an engine for given application.

Speed increase beyond n_N results in a fast decline in power output, determining therefore the position of maximum permissible speed n_{max}. In vehicle applications, this point is usually set just above the maximum-power-output speed. Vehicles designed for traction, however, are designed to operate at much lower engine speeds, since maximum torque and not power output determines performance limits.

The point of operation for maximum economy, corresponding to minimum specific fuel consump-

tion, coincides approximately with the speed of maximum torque. When transmission reduction ratios are properly selected, this economic optimum falls within the most frequently used part of the vehicle speed range. This is especially true for part-load operation, where differences in specific fuel consumption are particularly large.

Effects of Atmospheric Conditions: Maximum engine power developed is directly proportional to the weight of air inducted into the cylinder. Power output is therefore a function of the state of the air.

In gasoline engines, it is found that power is in direct proportion to barometric pressure (which changes with altitude) and approximately inversely proportional to the square root of absolute temperature. To permit comparison of engines on a basis that is independent of atmospheric conditions, performance data are measured experimentally on dynamometers and are recalculated to certain standard air conditions. These standards, which were established by SAE, are: 1. Temperature, T_o = 520 deg Rankine (60 F). 2. Barometric pressure, B_o = 29.92 in. Hg (dry air).

If engine power under standard air conditions is known, the effective power developed under any other set of conditions can be calculated from the equation:

$$P = \frac{P_o(B - B_v)}{B_o} \sqrt{\frac{T_o}{T}} \qquad (263)$$

where P is effective engine power under the given atmospheric conditions (hp), P_o is engine power under SAE standard air conditions (hp), T is ambient temperature (°R), B is barometric pressure at the carburetor air inlet (in. Hg), and B_v is vapor pressure of the air (in. Hg).

The effect of air humidity, expressed in Equation 263 as vapor pressure B_v is, except under seasonally extreme conditions, usually negligible in performance calculations.

In Diesel engines, effects of atmospheric conditions on power output are more complicated, since not all the air inducted into the cylinders actually participates in the combustion process. Data-standardizing formulas are therefore functions of many variables that pertain to specific characteristics of a given engine, for example, engine size, quality of the fuel-air mixing process, etc. As a rough approximation, the following correction equation can be used for compression-ignition engines:

$$P = \frac{P_o(B - B_v)}{B_o} \left(\frac{T_o}{T}\right) \qquad (264)$$

Atmospheric conditions can easily change engine output as much as 25 per cent. This is because air-intake temperature under the hood of an engine can rise to 200 F or higher, and air-intake pressures can be reduced substantially by increasing altitudes. Even daily variations at a given location can give a 10 per cent change in engine power.

The effects of air conditions and altitudes on engine power are graphically represented in Fig. 71. The plot allows the relative magnitude of these factors to be compared.

Engine Accessory Losses: Engine performance diagrams supplied to vehicle designers usually represent the power of the so-called "bare" engine. Since there is no generally ac[illegible] finition of this term, interpretation in each case should be carefully considered. This requires accurate knowledge of the conditions under which dynamometer measurements were actually taken in the laboratory.

Generally, the bare-engine performance diagram pertains to an engine stripped of all installations and accessories not essential to engine functioning and such accessories that are subject to in-

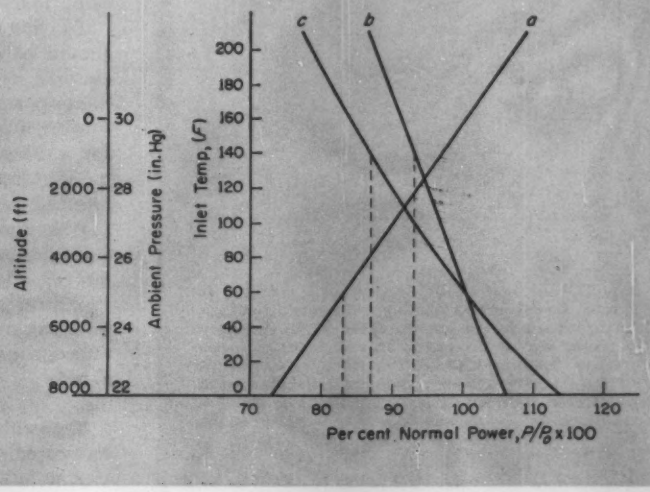


Fig. 71—Effects of carburetor-air intake conditions on internal-combustion engine power output. Normal power refers to engine rated power at SAE standard conditions (60 F and 29.92 in. Hg). Curve *a* shows power ratio vs. ambient pressure; curve *b* shows power ratio vs. intake temperature for gasoline engines; curve *c* shows power ratio vs. intake temperature for Diesel engines.

Example: Determine engine power ratio at 5000 ft altitude and 140 F air-intake temperature for gasoline and Diesel engines.

Gasoline engine:
$P = 0.83 \times 0.93P_o = 0.77P_o$

Diesel engine:
$P = 0.83 \times 0.87P_o = 0.72P_o$

dividual design and application requirements.

To obtain the power actually available at the output shaft, the power consumed by installations and accessories is subtracted from values given by the bare-engine power diagram. This gives a new diagram which represents the effective power available.

Installations and accessories found in the normal vehicle are reviewed in the following sections.

PUMPS AND DISTRIBUTOR: Water pump, fuel pump, oil pump and distributor drive form a special group since they are usually driven through internal connections from the engine block. As a rule, power requirements of these components are included in the bare-engine performance diagram. The fuel pump is sometimes an exception, since gravity feed may be used in the vehicle, making use of a fuel pump unnecessary.

MUFFLER: The muffler causes back pressure in the exhaust system and consequently power is lost in pushing through the burned gases. This power loss is proportional to the square of the engine speed and, depending on muffler resistance, reaches about 12 per cent at maximum power output. In high-performance engines, dual mufflers are used to reduce power losses to half of this value.

AIR CLEANER: Since the air cleaner is essentially a resistance element in the suction line, it causes a power loss proportional to the square of engine speed. Depending on its flow resistance, the average passenger-car air cleaner accounts for about a

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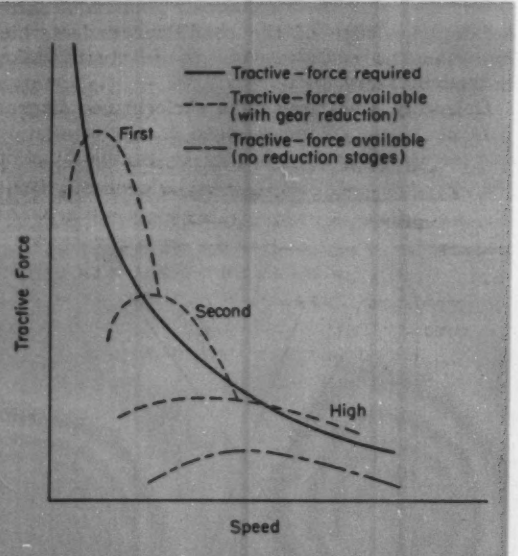


Fig. 72—Comparison of tractive force required by a typical vehicle and tractive force made available to the wheels by the engine. Plot shows that basic characteristic of the engine can be matched to the tractive force required curve by providing three or more speed-reduction steps in the transmission. Difference between "high" characteristic and "no transmission" characteristic is due to speed reduction in the vehicle differential.

3 per cent loss at maximum engine output.

GENERATOR: The generator has a varying power demand, depending on the instantaneous load in the electric circuit. At constant load, generator power-consumption characteristics have a linear relationship with speed. For the average passenger car, the generator requires about 2 hp at maximum engine power output.

FAN: Power requirement of the cooling fan is proportional to the third power of the speed and accounts for a considerable loss of power at high speeds. Shape of air-intake channels (grill) and operating speeds of the vehicle have an important effect on fan performance. On high speed vehicles, the natural flow of air often provides a substantial cooling effect. In fact, recent design developments have made it possible to automatically idle the fan when its function is not required, such as at high speeds and when starting a cold engine. On the other hand, vehicles working regularly at low speeds, or under intermittently stationary conditions, must depend entirely on the fan for cooling flow, since air flow due to vehicle speed is negligible. In rough approximation, an average passenger-car engine requires a fan with 1 hp power consumption at medium speeds. Power requirements increase about eight times when speed doubles.

HYDRAULIC PUMPS: Use of hydraulic pumps to provide power for auxiliary functions is increasing rapidly. On passenger cars fluid pressure is used for power steering, while hydraulically powered work-saving devices on agricultural and industrial vehicles are standard equipment.

The power consumption of a hydraulic pump can be calculated from the equation

$$P = \frac{Qp}{1714\,\eta} \qquad (265)$$

where Q is volume output (gpm), p is pressure (psi) and η is total pump efficiency, usually around 75 per cent. The power-consumption characteristic of a pump is basically in straight-line proportion with speed. At very high speeds, pump efficiency usually decreases, resulting in higher power consumption.

To determine how much of pump power should be subtracted from the bare-engine output, consideration must be given to the variation of pump-power demand with driving conditions. Power steering and other auxiliary equipment, for example, reach the peak power-consumption point when the vehicle is stationary and show reduced requirements at normal driving speeds.

Power requirement of all accessories should be carefully evaluated for each application and then plotted additively against engine speed. The final graphical summation is then subtracted from the bare-engine power diagram. The result represents effective power delivered to the transmission input shaft.

Transmission Characteristics: It has been shown in preceding sections that the internal-combustion engine is not in itself suited for vehicle propulsion,

since torque requirement for initial acceleration can be met only with the help of a change-gear transmission. The function of the transmission is to transform the torque-speed relationship of engine output into a form which more closely corresponds to actual driving demands, Fig. 72. This transformation is performed by the following means:

1. By the transmission itself, which can either have the form of a manual gear-shift transmission or that of a gear-reduction stage plus a hydraulic element such as a fluid coupling or a torque converter. Reduction ratios must be properly chosen in number and magnitude if the desired effect is to be obtained.

2. By a rear-axle gear, which gives, as a general rule, a constant reduction ratio of 3.5 to 6.5 through a hypoid gear pair. The rear-end ratio is determined by the usual practice requiring direct (nonreducing drive) drive through the transmission in high gear.

3. On vehicles requiring extremely high torques at low speeds, additional gear-reduction stages are usually placed at the drive wheels.

Power transmission between the engine output shaft and the driving wheels involves the following additional factors as power-consuming elements:

1. *Clutch efficiency,* amounting to about 99 per cent.

2. *Transmission power consumption,* originating in friction between gears and oil-churning losses. Gear friction is proportional to power transmitted and depends on gear-surface finish and quality of lubrication. Oil churning losses are proportional to approximately the third power of speed and are a function of oil viscosity. These factors result in an average transmission efficiency of 97 to 95 per cent for each gear pair, including final gear reductions. Torque-converter efficiencies, which vary more widely with operating conditions, are discussed in the next part of this series.

3. *Efficiencies of bearings and joints,* assumed for a passenger car to be from 98 to 99 per cent.

4. *Wheel slip.* A driving wheel in one full turn makes a translatory advance which is less than the circumference of the circle corresponding to the rolling radius of the tire. The difference is explained by the slip of the driving wheels (Part 1) and depends mainly on the nature and condition of the ground surface. This effect is expressed as drive efficiency or slip factor, with values of approximately 95 to 98 per cent for normal highway surfaces.

Total efficiency of the drive system between engine output shaft and drive wheels is the product of all component efficiency factors. The following are representative average overall efficiencies for a vehicle with a change-gear transmission:

1. In direct gear, 90 per cent
2. In other gears, 85 per cent
3. Drives with very high reductions (final drive), 75 to 80 per cent.

Power loss in the transmission is manifested as heat in the gear-box oil, bearings and other parts engaged in power transmission. The heat is eventually transmitted to the outside air by convection and radiation.

In the next part of this series, two representative vehicles—a passenger car and an industrial truck—are matched to their powerplants and detailed calculations of resulting vehicle performance are illustrated.

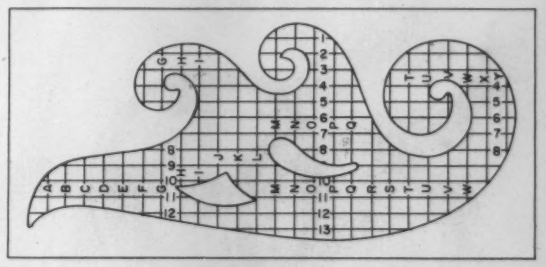
Mechanics of Vehicles

In "Braking Performance Limits," Part 12 of the series by Jaroslav J. Taborek, the example problem accompanying Fig. 64 was misplaced. It was intended to illustrate use of Fig. 67.

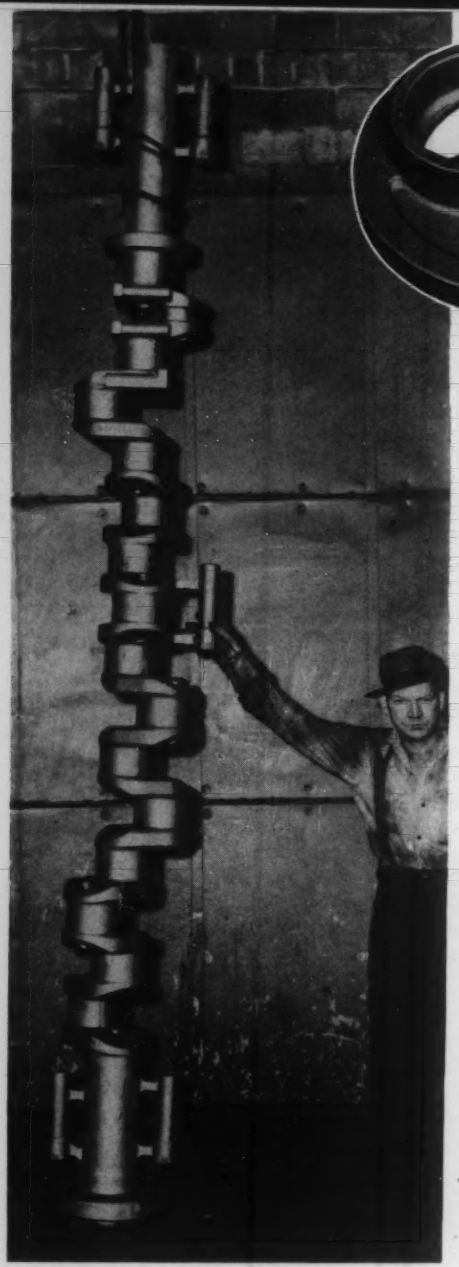
Tips and Techniques

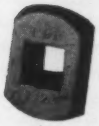
French Curves

Symmetrical objects are frequently difficult to draw with French curves due to the problem of properly aligning the curve. Drawing the same curve a number of times presents the same problem. The curves can be adapted to perform such work by adding lines on one face of the curve. These lines provided reference points at their intersections to permit the curve to be repositioned in the same relationship to center or reference lines when drawing matching curves. These lines also provide divisions along the edge to permit the same section of the curve to be used each time. — CLINT MCLAUGHLIN, *Rockaway, N. Y.*



Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.





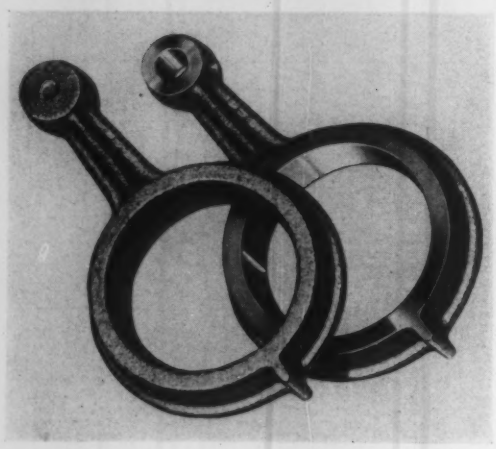
Fatigue properties of

By FRANZ R. BROTZEN and
Rice Institute
Houston, Texas

Good strength, fatigue resistance, high damping capacity, and good wear resistance are some of the major properties of gray iron. Knowledge of these properties will enable the designer to select a type of gray iron suitable for applications where fatigue-inducing conditions occur.

GRAY IRON exhibits excellent behavior in fatigue under a variety of conditions. It has extremely low notch sensitivity and is very serviceable for crankshafts and similar applications where fatigue considerations are important criteria of design. Ease of casting intricate shapes, facility of improving properties by heat treatment, excellent machinability, and relatively low cost provide the economic advantages of using gray iron. Fatigue properties of gray or unalloyed irons and low-alloy gray iron, generally with less than three per cent total alloy content, will be discussed in this article.*

Endurance Limit and Endurance Ratio: The limiting stress sustained by a metal without fracture after a very large number of cycles of alternating stress (usually 10 million for ferrous materials) is the endurance limit in fatigue. Values for gray iron ranging from 12,000 to 32,000 psi have been reported for this limiting stress. Endurance limit generally increases with increasing Brinell hardness and compressive strength, although considerable scatter is observed.



*Based on "Properties of Gray Iron," from *Gray Iron Castings Handbook*, edited by Charles F. Walton, technical director, Gray Iron Founders' Society.

Table 1—Endurance Limit and Ratios for Various Gray Irons

Type of Iron	Tensile Strength (psi)	Endurance Limit (psi)	Endurance Ratio
Pearlitic	41,000	19,000	0.46
	42,100	19,000	0.45
	48,600	21,300	0.44
	52,900	23,500	0.45
Acicular	63,900	24,600	0.39
	65,500	24,600	0.38
	65,900	25,800	0.39
	76,000	25,800	0.34

GRAY IRON

JOHN F. WALLACE
Case Institute of Technology
Cleveland, Ohio

The endurance ratio, obtained by dividing limiting fatigue stress by tensile strength, is widely used to compare fatigue behavior of metals. Endurance ratios between 0.33 and 0.60 have been reported for gray iron. This wide variation in endurance ratio is the result of the wide diversity of cast irons tested under different testing conditions. Endurance ratio is generally lower for higher strength irons, as demonstrated for several classes and types of gray iron[1] in Tables 1 and 2.

Influence of Stress Conditions: Values of endurance ratio and endurance limit must be used with caution because they do not depict behavior under various combinations of stress state or include effect of over-stressing or notches. Rupture strength in bending is greater than actual tensile strength because of different stress-strain characteristics of gray iron in tension and compression. Correspondingly, calculated endurance limit from bending fatigue tests can be as much as 25 per cent above actual value. This variation actually depends on the type of iron and dimensions of the specimen. Endurance limit for axial loading has been shown by various investigators to vary between 59 and 94 per cent of the limiting fatigue stress for bending, but is frequently close to 75 per cent of limiting stress in bending.

The favorable strength of gray iron in compression and torsion results in excellent fatigue properties under these types of stress. Repeated loading in compression alone yields a relatively high endurance limit with an endurance ratio of 0.40 to 0.70. The endurance ratio for gray iron in torsion is generally about 0.40, although it is higher

[1]References are tabulated at end of article.

Table 2—Endurance Limit in Bending for Different Classes of Gray Iron

Class	Endurance Limit (psi)	Class	Endurance Limit (psi)	Class	Endurance Limit (psi)
20...	about 10,000	35...	16,000-17,500	50...	24,500-27,500
25...	11,500	40...	17,500-19,500	60...	about 29,500
30...	13,700-15,500	45...	21,500-25,500	70...	about 31,500

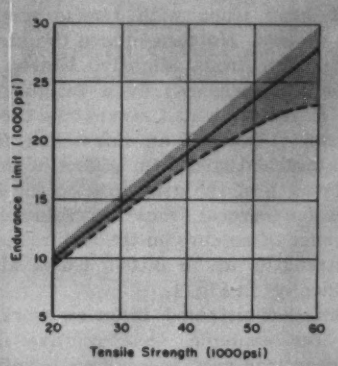


Fig. 1—Relationship between tensile strength and endurance limit as determined with smooth and notched test bars. Average values for smooth and notched bars are indicated by the shaded portion and dashed line respectively.

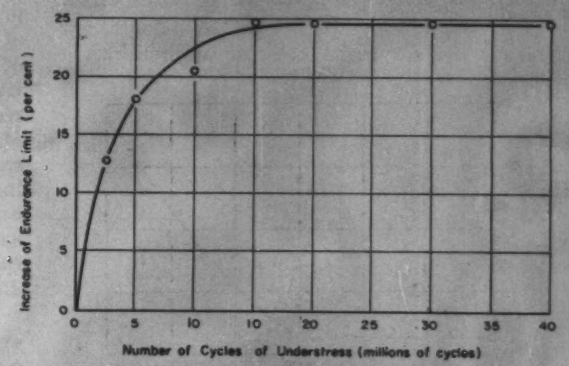


Fig. 2—Increase in endurance limit of gray iron as affected by understressing. Specimen exhibited a tensile strength of approximately 20,000 psi and was understressed at 9000 psi. Fatigue limit of the specimen increased with increasing cycles of understressing to a minimum of approximately 25 per cent.

for lower strength irons. The ratio of endurance limits in torsion to those in bending have been found to be as low as 0.75 and as high as 1.25.

Endurance ratio is usually higher when the load is applied from zero to a maximum in only one direction. In one study the endurance limit was found to be 19,000 psi for a complete reversal in bending, but 23,000 psi for bending from zero to a maximum. A similar increase was also noticed when fatigue testing was conducted in torsion. Limiting fatigue strength and endurance ratio of several high strength irons are shown for a variety of different fatigue loading conditions[2] in Table 3.

Table 3—Tensile and Fatigue Strength of Gray Irons

Gray Iron No.	1	2	3	4	5
Tensile strength (psi)	44,000	48,000	55,000	56,500	76,500
Endurance limit, complete reversal bending (psi)....	19,000	21,000	22,000	22,000	25,000
Endurance ratio, complete reversal bending	0.43	0.44	0.40	0.39	0.33
Endurance limit, half-cycle bending, 0-max (psi)	23,000	32,000	27,000	33,000	38,000
Endurance ratio, half-cycle bending, 0-max	0.52	0.67	0.49	0.58	0.50
Endurance limit, complete reversal torsion (psi)	16,000	16,500	21,000	20,000	22,000
Endurance ratio, complete reversal torsion	0.36	0.34	0.38	0.35	0.29
Endurance limit, half-cycle torsion, 0-max (psi)	23,000	25,000	26,000	33,000	29,000
Endurance ratio, half-cycle torsion, 0-max	0.52	0.52	0.47	0.58	0.38

Table 4—Influence of Notching on Endurance Limit

Tensile Strength (psi)	Endurance Limit Unnotched (psi)	Endurance Limit Notched (psi)	Fatigue Stress Reduction, K factor
20,000	9,200	9,200	1.00
25,000	11,900	11,400	1.05
29,800	15,000	13,700	1.10
33,600	22,000	15,700	1.40
36,500	19,500	16,300	1.20
42,600	23,300	19,000	1.26

Table 5—Endurance Limit and Endurance Ratio of Gray Iron*

No.	Copper (%)	Tensile Strength (psi)	Endurance Limit (psi)	Endurance Ratio
1	0	48,500	23,000	0.47
2	0.53	47,500	19,000	0.40
3	0.99	50,000	22,000	0.44
4	1.45	53,000	24,000	0.45
5	1.98	54,500	24,000	0.44
6	3.10	56,000	23,000	0.41

*Containing 3.15 per cent carbon, 1.50 per cent silicon, alloyed with copper.

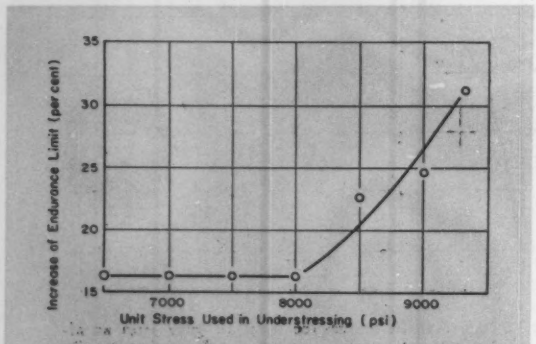


Fig. 3—Increase in endurance limit as influenced by the unit stress used in understressing a gray iron. Indications show that this increase in endurance limit does not occur to an important extent in high-strength irons.

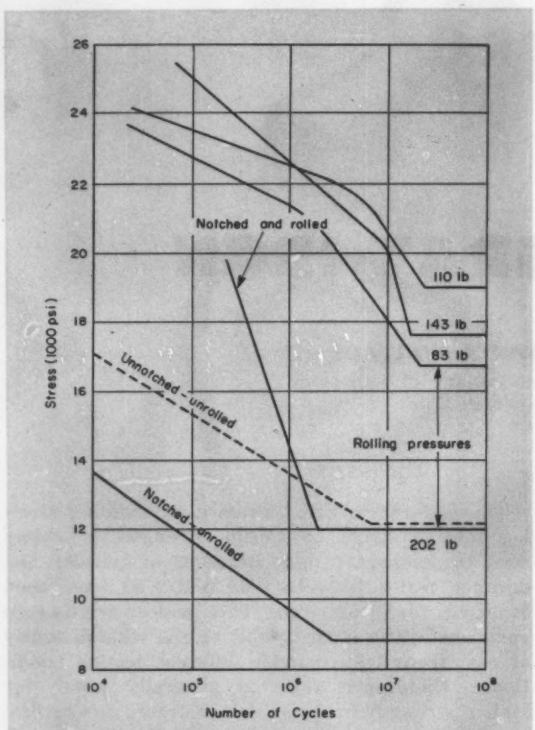


Fig. 4—Influence of rolling on fatigue strength of notched and unnotched test bars of gray iron with ferritic microstructure. Fatigue limit was improved 110 per cent by optimum pressure. Pressures above optimum result in surface damage and reduced endurance limit of the ferritic iron test bar.

Notch Sensitivity: Introduction of stress raisers such as notches has little influence on fatigue properties of gray irons with tensile strengths of 40,000 psi or less. Notches reduce the strength of higher strength irons slightly. Notch sensitivity is generally measured by a fatigue stress reduction or K factor, which represents the ratio of the endurance limit of an unnotched fatigue specimen to a notched specimen. Effect of increasing tensile strength of the gray iron on the K factor is shown for several irons[3] in Table 4. The average influence of notches on the endurance limit for tensile strengths up to 60,000 psi is also indicated graphically[4] in Fig. 1.

It has been demonstrated in some work with crankshafts, for example, that relative dimensions of the gray iron part, in addition to influence of notches, can be changed to increase endurance limit. Stepped bars with different diameters show increased torsional fatigue limit compared to crankshaft sections. A reduction in all dimensions by 50 per cent increased limiting fatigue stress in torsion by 28 per cent for gray iron.

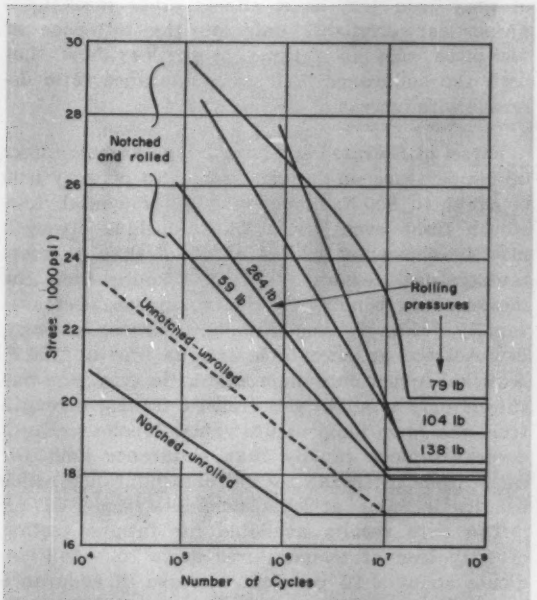


Fig. 5—Influence of rolling on fatigue strength of notched and unnotched test bars of gray iron with pearlitic microstructure. Endurance limit was improved 20 per cent by optimum pressure.

Overstressing and Understressing: When gray iron and other metals are subjected briefly to stresses above the endurance limit, the eventual limiting fatigue strength is usually reduced. Reduction in endurance limit by overstressing increases with stress and number of cycles. However, if the material is understressed by subjecting it to cycling or static stresses below the endurance limit, the resulting limiting fatigue strength is increased. Progressively increasing understress may improve endurance limit.

A study of the effect of overstressing on fatigue limit of gray iron at stresses up to 1.3 times the endurance limit has shown the excellent ability of cast iron to withstand overstress. Overstresses of 10 per cent for cycle ratios up to 80 per cent did not appreciably affect the fatigue limit of unnotched specimens. For a ¼-in. wide, 0.330-in. deep, square notch, overstressing actually improved the endurance limit of the iron. Only with a high degree of overstressing in the unnotched specimens did a significant decrease in fatigue limit occur. Ability to withstand overstress is somewhat less for high-strength irons.

The beneficial effect of understressing on fatigue properties can be demonstrated, although results are confined to low-strength irons. A gray iron with a tensile strength of approximately 20,000 psi and an endurance limit of 9300 psi was understressed at 9000 psi to obtain the increases in endurance limit[5] shown in Fig. 2. Fatigue limit increased with increasing cycles of understressing to a maximum of 25 per cent. When this same iron was understressed for 20 million cycles at various stresses, the higher the understress employed, the greater the increase in fatigue limit obtained[5] as shown in Fig. 3. There are indications, however, that this increase in endurance limit does not occur to an important extent in high-strength irons.

Effect of Surface Rolling and Surface Finish: Fatigue properties of gray iron can be measurably improved by surface rolling. In some recent work performed with V-notched specimens of ferritic and pearlitic gray irons, the notch was rotated between hardened steel rollers. Various pressures were applied, thereby increasing tensile strength and inducing compressive stresses into the surface layers. Results indicate that an optimum rolling pressure exists for improving fatigue properties and that higher pressures damage the surface and reduce endurance limit. Fatigue limit of ferritic iron was improved 110 per cent by the optimum pressure,[6] Fig. 4, while pearlitic gray iron showed a 20 per cent increase in endurance limit,[6] Fig. 5. *S-N* curves for unnotched-unrolled and notched-unrolled metal are shown in both cases for comparison. It has been shown that fatigue strength of a cast crankshaft can be improved by cold rolling or roll polishing.

As might be expected from the low notch sensitivity of gray iron, its fatigue properties are

Table 6—Effect of Heat Treatment on Endurance Limit of Alloyed Gray Irons

Iron No.	Heat Treat*	Hardness (bhn)	Impact, Izod (ft-lb)	Endurance Limit (psi)	Endurance Ratio	Increase in Tensile Strength (per cent)	Increase in Endurance Limit (per cent)
1	AB	217	18	17,500	0.35	..	..
2	ABC	311	16	18,000	0.27	32	3
3	AE	248	15	17,500	0.28	25	None
4	AF	255	21	22,500	0.32	41	29
5	GB	248	18	21,000	0.32	31	20
6	A	197	..	16,000	0.34	..	..
7	ACH	255	..	15,000	0.23	40	—6
8	A	207	..	17,000	0.33	..	..
9	ACD	293	..	15,500	0.20	53	—8
10	A	217	..	16,500	0.34	..	..
11	AE	277	..	16,500	0.28	..	None
12	A	...	..	21,000	0.44	..	..
13	ACJ	...	..	25,000	0.33	59	19

*A—Mold-cool to room temperature.
B—Stress relieve at 1050 F.
C—Oil quench from 1600 F.
D—Temper at 1050 F for 2 hr.
E—Austemper; oil quench from 1600 F to 900 F, hold for 16 hr.
F—Austemper; oil quench from 1600 F to 650 F, hold for 16 hr.
G—Shakeout from mold at 1600 F, air cool.
H—Temper at 1130 F for 2 hr.
J—Temper at 1000 F.

little affected by surface finish. Dependence on surface condition was shown, however, when the fatigue limit of a high-strength iron was improved approximately 20 per cent by removing the cast surface layer by machining.

Effect of Structure, Composition, Section Size, and Heat Treatment: Fatigue properties of gray iron are very sensitive to structure, particularly graphite size and distribution. Endurance limit is usually considerably better in gray irons with fine graphite, and is even more affected by this constituent than is the tensile strength. Effect of original as-cast structure still influences endurance limit after heat treatment. When tensile strength is increased by alloy additions, endurance ratio (not necessarily endurance limit) is generally decreased as shown for copper additions[7, 8, 9] in Table 5.

Fatigue properties are also influenced by heat treatment of gray iron castings,[10, 11] Table 6. It has been demonstrated by quenching and tempering and by isothermal quenching that endurance limit does not increase as rapidly as the strength is increased. Thus, endurance ratio decreases and notch sensitivity increases as strength is increased by heat treatment.

High-tensile strength irons, such as those with an acicular structure, usually exhibit a lower endurance ratio, although some of these irons have been reported with endurance ratios as high as 0.46. The lower strength austenitic gray irons in the 29,000 to 35,000 psi tensile strength range generally exhibit an endurance ratio of slightly more than 0.50.

Increasing section size reduces fatigue strength of gray iron just as it affects other mechanical properties. Available data on the influence of test-piece size on fatigue properties show that both the endurance limit and endurance ratio decrease with increasing section size.

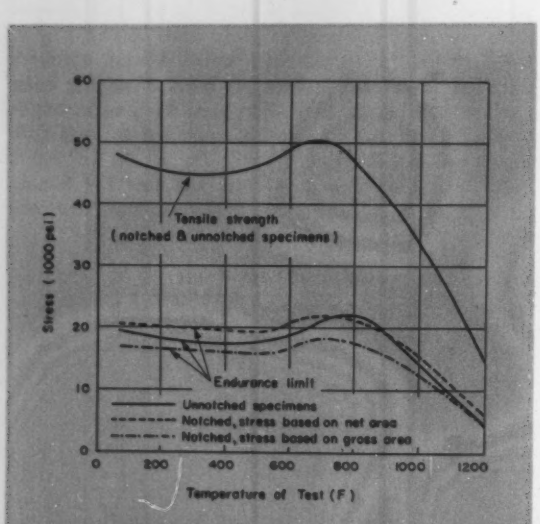


Fig. 6—Influence of elevated temperatures on tensile strength and endurance limit of a gray iron in notched and unnotched test specimens. Endurance limit decreases rapidly above 800 F. Austenitic gray irons, however, show acceptable fatigue life to 1160 F.

Effect of Elevated and Low Temperatures: Effect of temperature on fatigue properties of gray iron is slight to 800 F. Some results for special, low-silicon irons even indicate that fatigue strength may be somewhat higher at 400 F than at room temperature. Above 800 F, endurance limit, as measured by bending fatigue specimens, decreases rapidly,[12] Fig. 6. Austenitic gray irons, however, demonstrate an acceptable fatigue life to 1160 F. A nickel-copper-chromium austenitic gray iron has shown only a slightly decreased fatigue strength from the room temperature value. Tensile strength decreases more rapidly than endurance limit for these irons, with the result that endurance ratios usually increase at high temperatures.

The only results available for fatigue testing of gray iron at temperatures down to −50 F indicate about a 25 per cent increase in endurance limit when the temperature is decreased from 80 to −50 F. Notch sensitivity of the gray iron was not altered by this decrease in temperature. While endurance limit might not improve as much with other irons over this temperature range, it does appear that low-temperature fatigue properties are at least equivalent to those at room temperature.

REFERENCES

1. J. W. Grant—"Notched and Unnotched Fatigue Tests on Flake and Nodular Casts Iron," British Cast Iron Research Association, *Journal of Research*, Vol. 3, April, 1950, pp. 333-354.
2. H. F. Moore and J. S. Picco—"Fatigue of High-Strength Cast Irons," *Transactions*, American Foundrymen's Association, Vol. 32, 1934, pp. 525-542.
3. J. B. Kommers—"The Static Fatigue Properties of Some Cast Iron," *Proceedings*, American Society for Testing Materials, Vol. 28, No. 2, 1928, pp. 174-204.
4. C. H. Lorig—"Cast Irons," *Product Engineering*, Vol. 11, May, 1940, pp. 209-212.
5. J. B. Kommers—"The Effect of Understressing on Cast Iron and Open-Hearth Iron," *Proceedings*, American Society for Testing Materials, Vol. 30, No. 2, 1930, pp. 368-383.
6. G. N. J. Gilbert and K. B. Palmer—"The Influence of Surface Rolling on the Fatigue Properties of Flake Graphite and Nodular Graphite Cast Irons," British Cast Iron Research Association, *Journal of Research*, Vol. 5, October, 1954, pp. 447-764.
7. C. H. Lorig and V. H. Schnee—"Damping Capacity, Endurance, Electrical and Thermal Conductivities of Some Gray Cast Irons," *Transactions*, American Foundrymen's Association, Vol. 48, December, 1940, pp. 425-448.
8. G. N. J. Gilbert—"Fatigue Properties of Cast Iron," British Cast Iron Research Association, *Journal of Research*, Vol. 5, December, 1953, pp. 94-108.
9. J. W. Donaldson—"Fatigue and Impact Strengths of Cast Iron," *Foundry Trade Journal*, Vol. 63, August 8, 1940, pp. 91-93, 96.
10. T. E. Eagan—"Effect of Heat Treatment on the Endurance Limit of Alloyed Gray Cast Iron," *Foundry Trade Journal*, Vol. 78, April 4, 1946, pp. 361-365.
11. R. S. Burpo—"Changes in Endurance Limit of Alloyed Gray Irons Caused by Heat Treatment," *Materials and Methods*, Vol. 25, January, 1947, pp. 119-121. (T. E. Eagan, *Transactions*, American Foundrymen's Society, Vol. 54, 1946, pp. 230.)
12. W. L. Collins and J. O. Smith—"Fatigue and Static Load Tests of High-Strength Cast Iron at Elevated Temperatures," *Proceedings*, American Society for Testing Materials, Vol. 41, 1941, pp. 797-810.

Forced-Air Cooled Refrigerator

The condensers in the 1958 Westinghouse refrigerator line are made of wire and tubing, not the refrigerated plates as stated on Pages 144 and 145 of the November 14, 1957, issue of MACHINE DESIGN. The refrigerated plates are made of a preformed sheet-and-tube design.

The Personal Side of Engineering

By **EDWIN C. NEVIS**
Personnel Research and Development Corp., Cleveland, Ohio

Applying Your Creative Potential

A WIDELY held assumption, particularly among scientific and technical people, is that the main factor in solving a technical problem is training, intelligence, and technical know-how. And in thinking about creativity or looking for people to solve difficult problems, we think of those who possess a high level of intellectual ability.

Intellectual level of an individual is important, particularly for complex, abstract problems. But a great many personality and temperament factors are also related to the ability to solve problems, as well as to the way a problem is conceived and the way in which a solution is undertaken. In describing the approach of the competent, capable worker, we tend to use such adjectives as "persistent," "curious," "absorbed in what he is doing," "flexible," and so on. Yet these terms refer more to the *quality* of a person's intelligence rather than to his sheer capacity. The implication is that a man's potential is applied in a way which is characteristic of his general view of life and of himself.

The way we organize our problem-solving depends upon the kind of person we are, the experiences we have undergone in our life, and the values which we stress as being important. If we are theoretical-minded, we will emphasize the discovery of truth in our approach to a problem. If we have a high need for social acceptance, we may be more likely to emphasize the use to which our results are put and the acceptance we can win from other people for solving the problem. If we are power-oriented, our approach to the problem may emphasize the status and prestige we can achieve in return for our solution. And each of these emphases will lead us to a somewhat different approach to the problem, though at all times our intellectual power may be in use.

Not only do deeply engrained, life-long values influence our approach to problems, but also day-to-day fluctuations in our feelings and our attitudes toward our job, the people who work with us, and those under whom we work. It is not uncommon to find an engineer or scientist who appears to be momentarily stopped in his solution to a problem, but who moves quickly ahead after he has resolved some supposedly unrelated personal problem or conflict.

Some clear-cut patterns in problem-solving stand out. For example, certain individuals see each problem as a tremendous challenge and a stimulus to move into action immediately. These action-oriented people do not give long, intense analytical treatment to a problem, but rather make a quick survey of what is required and act fast. Such individuals tend to show up well in emergency situations where the kind of solution is not necessarily as important as the speed with which the problem is attacked.

A highly theoretical person, however, may sit back and, at a bit of distance, attempt to form an abstract conception of the problem. Such individuals are particularly adroit at planning and organizing an approach to problems. At times, they do not give as much attention as might be desired to gathering empirical facts, but their solutions are generally well-organized, coherent, and frequently sophisticated.

Then, there is the person who sees each problem in relation to other problems and searches for the opportunity to perform on a broad basis. Such individuals generally have a good deal of intellectual initiative and enterprise and are frequently valuable in defining problems to be attacked—sometimes more so than in actually solving them.

Another type is the individual who is extremely good at gathering specific facts and making careful observations and plans. This carefully detailed approach can often serve the needs of more theoretically inclined individuals, who may be more able to do the broad, basic planning for research

and design projects. These few examples barely indicate the range of possible problem-solving approaches.

Individual differences or "styles of performance" must be taken into consideration in practical situations. Appreciation of the quality of a person's intellectual approach can be helpful in assigning tasks which utilize his particular style fully. Thus, we might have two equally bright people in terms of basic intellectual capacity. But one might be better at taking quick action on specific, limited projects, and the other more capable of long-range, abstract planning.

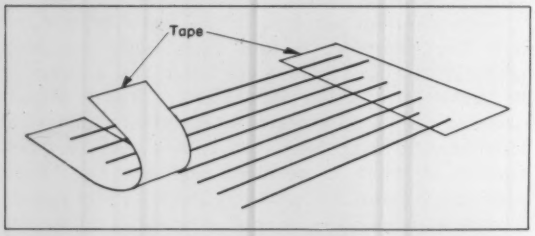
Appreciation of these factors can also help us understand the viewpoints of other people, and particularly, help us realize why people with intelligence and experience do not always solve problems presumably within their grasp. Finally, appreciation of these differences tells us that it is somewhat improper to think of people only as being more or less intelligent. We need to think of ability in terms of qualitative, as well as quantitative, differences.

For these same reasons, it may be best to consider problem-solving as an art, and to think of the scientific method as a tool in the service of the "artist." Since they are engaged for the most part in applied problem-solving, engineers might try to evaluate the intangible and emotional factors in their own and their colleagues' problem-solving behavior. This analysis can foster greater mutual understanding and enhance productivity.

Tips and Techniques

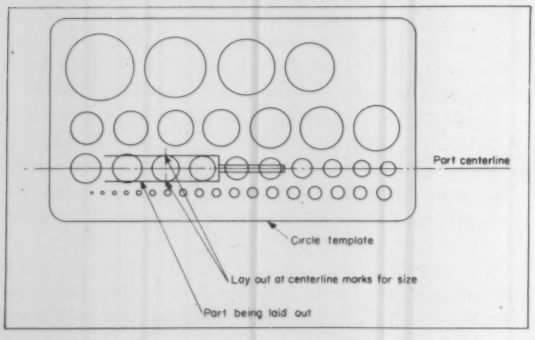
Lines of Equal Length

When ruling many close parallel lines, as for tables on a drawing, strips of masking tape will help assure equal lengths. Two strips of tape are placed perpendicular to the direction of the lines,



spaced to mark the ends of the lines. The tapes speed drawing by eliminating the exact starting and stopping points. When the tapes are stripped, the ends of the lines are all even and sharp.—JOHN G. STEFFEY, *W. H. Reisner Mfg. Co. Inc., Hagerstown, Md.*

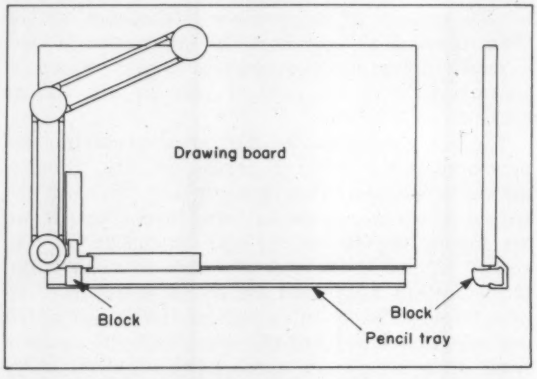
Symmetrical Parts



Much time can be saved by using a circle template, in place of a scale, for laying out or drawing small parts which are symmetrical about a centerline, such as bolt heads, shafts, etc. The centerline of the part is lined up and the tangent points (90 deg) are marked. This technique is especially helpful on small parts, where dividing 1/16s on a scale is awkward.—PAUL S. PETERSEN, *General Mills Inc., Mechanical Div., Minneapolis, Minn.*

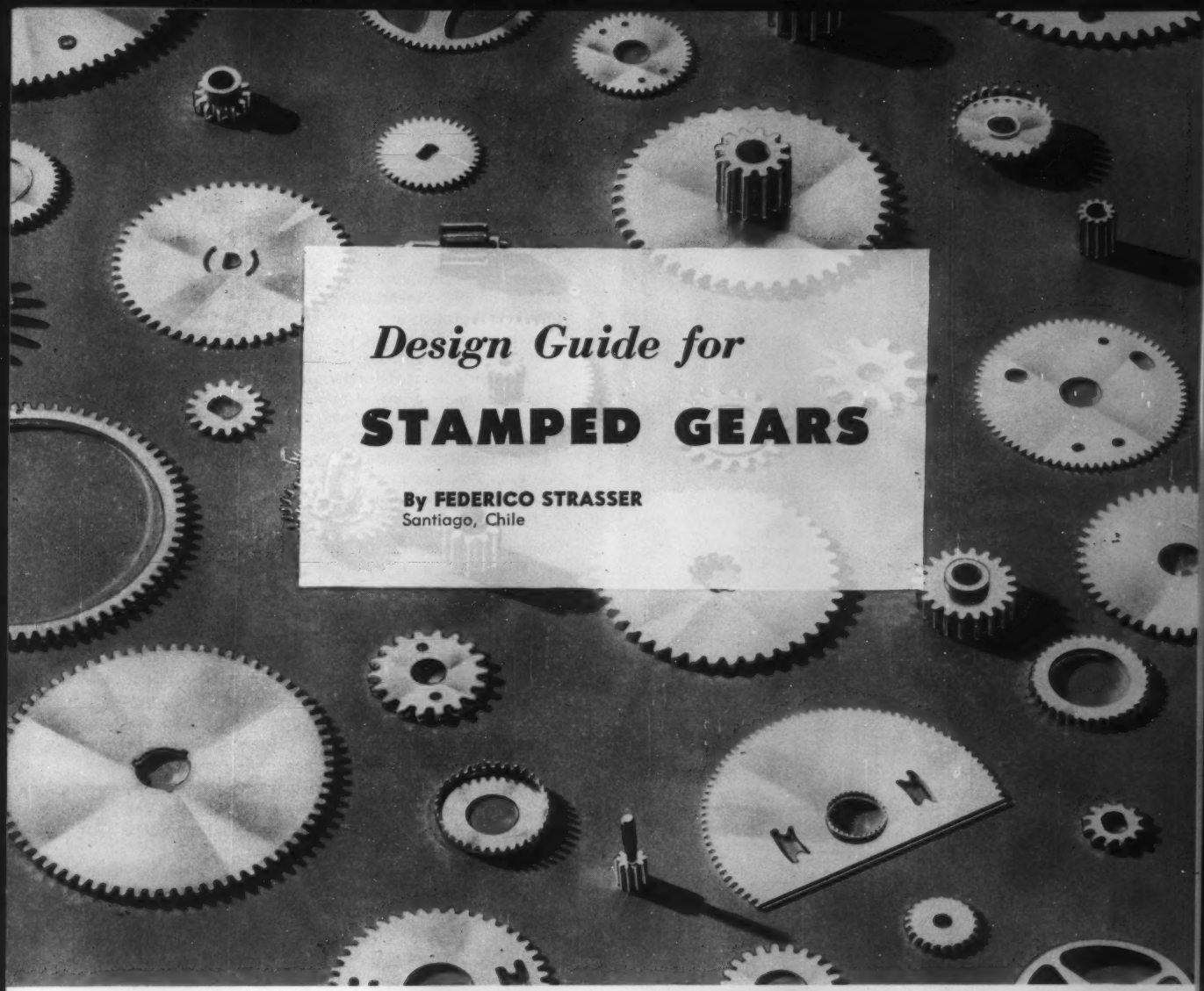
Drafting-Machine Block

Unless a drafting machine is counterbalanced, it will slide off a board tilted at a steep angle. To prevent this occurrence, a 2-in. wide block can be



made to fit the pencil tray of the drawing board. The block must be high enough to catch the scale. When the machine is not in use, it can be set against the block.—ROBERT WEBB, *Oshkosh, Wis.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.



Design Guide for
STAMPED GEARS

By **FEDERICO STRASSER**
Santiago, Chile

INEXPENSIVE, lightweight gears for light to medium-duty applications can be designed for stamping from sheet metal. When gears are produced partially or entirely by stamping, tooling costs may be greater than when made by other methods, but if the quantities are large, final costs can be very low. Depending upon production requirements, justifiable tooling costs, and precision of tooth-form required, gears can be stamped complete including the teeth, or the gear blanks can be stamped and the teeth produced by conventional gear-cutting methods.

Stamped gearing offers the designer a number of advantages which are important in lightweight, low-cost gear trains:

1. Shapes are almost unlimited, providing conventional press-tooling can produce them. Tabs, stops, nontoothed portions, holes, extrusions, and bosses are readily incorporated in one-piece designs without necessity of extensive machining or assembly of small parts.
2. Sizes are relatively unlimited within the range of practical gearing requirements for the thicknesses available. One major supplier lists a range of thicknesses from 0.006 to 0.250-in. and a pitch-diameter range from 3/16 to 10 in.
3. Tolerances are good. As stamped, gear teeth can be readily produced to within 0.002-in. of required tooth profile. While expensive tooling is required, stamped teeth can be die shaved to within 0.0005-in. of desired profile. Stamped gearing can be held to within ASME Commercial Class 4 requirements. Typical pitches for stamped gears are 8 to 120. Naturally, when stamped blanks are machined with conventional gear-cutting methods, similar tolerances are secured as with any other type of blank.
4. Weight is a decided advantage. Sheet-metal

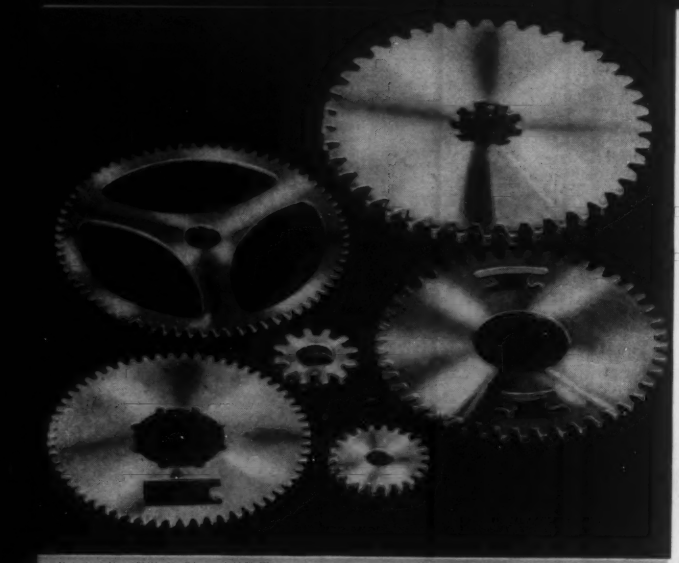


Fig. 1—Stamped flat gears may be designed to include lightening cutouts, spring pockets and similar details. Courtesy Winzeler Mfg. and Tool Co.

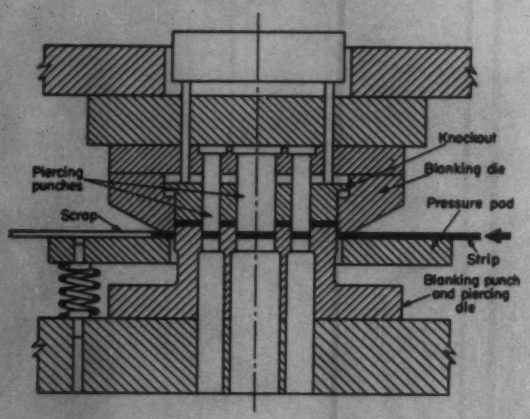


Fig. 2—Compound dies pierce the center hole, blank the exterior, and pierce other required openings simultaneously. Concentricity depends only upon the precision with which the die is made, and is normally very close.

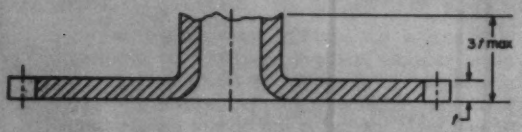


Fig. 3—Light hubs may be formed by extruding the center hole. The ID can be held to very close tolerances, but the end of the extrusion will be ragged and no precise height can be held.

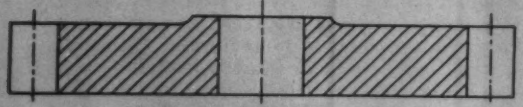


Fig. 4—Swaging, a kind of cold forging, may be used to produce raised hubs or to force the teeth into a female die for good finish and precision.

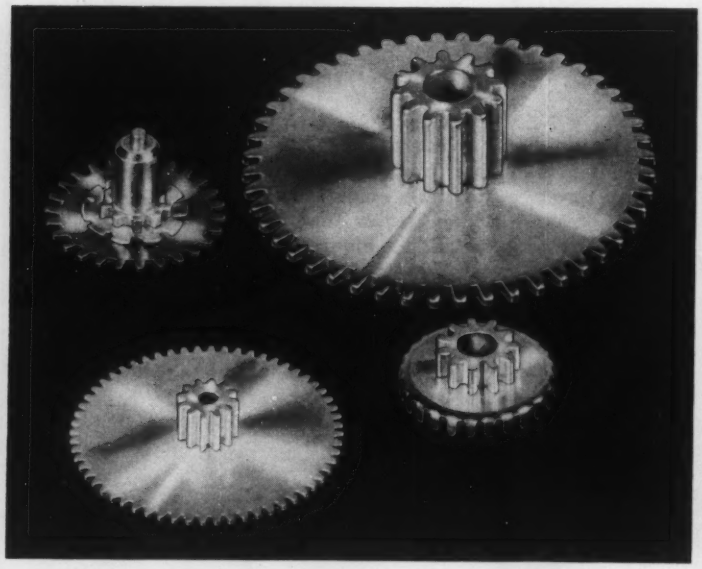
gears are inherently lightweight. By piercing lightening holes, this advantage can be increased.

5. Surface smoothness depends on the finish of the original sheet material. Normally very good, this finish can be whatever is required.
6. Material choice is wide, including all of the ferrous and nonferrous metals which are normally adaptable to the stamping process.
7. Production, in pieces per man-hour of direct labor or per machine-hour, can be very high. This is a function of the type of tooling and machine used to produce the part. For high-volume stampings, the direct labor is virtually negligible when production is run with progressive dies on automatic presses.
8. Finishing costs are low and the selection of finishes is very broad. If dies are maintained in good condition, little or no deburring is required. The selection of coatings and platings available is the same as for other sheet-metal products.

Naturally, stamping of gears has its disadvantages. Presses are expensive, and hourly machine costs may be higher than for other production methods. Tooling costs are high, and can be very high. Little or no design changes can be made without constructing entirely new tooling. Tooling lead time, compared with other gear-production methods, is adverse. Except for temporary or short-run tooling, the die design, tryout and development may take months. However, certain specialty firms offer standardized gears from their own tooling. When a design permits their use, these gears can be employed without waiting for tooling to be built and without high tooling costs for short runs.

Flat Gears: Sheet-metal gears can be produced

Fig. 5—Stamped gears can be assembled to separate hubs, pinions or shafts by staking, brazing and other methods. Courtesy Winzeler Mfg. and Tool Co.



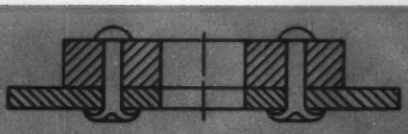


Fig. 6—Riveting is a common way of joining composite gears. However, to assure concentricity between bore and pitch diameter of teeth, a subsequent chucking and reaming operation is normally needed.

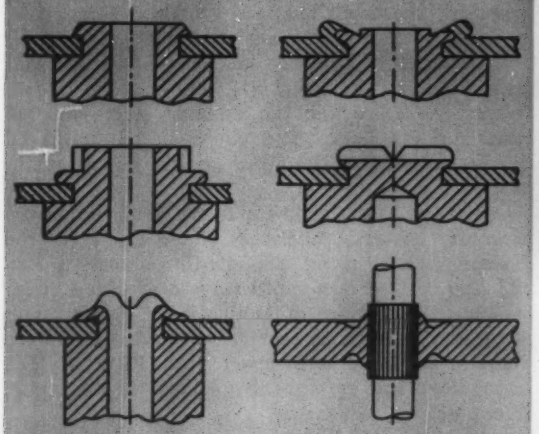


Fig. 7—Staking is widely used for joining gear assemblies and offers good concentricity.

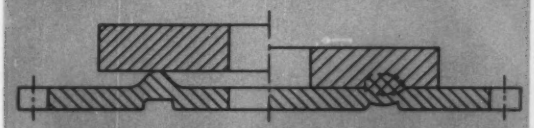


Fig. 8—Resistance welding produces a low-cost assembly but requires reaming the bore for good concentricity.

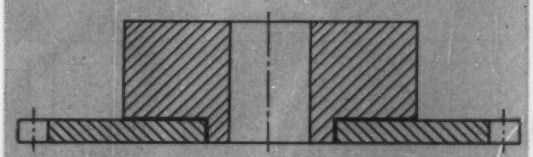


Fig. 9—Soldering or brazing offers good concentricity after assembly. Most nonferrous composite gears are joined in this way.

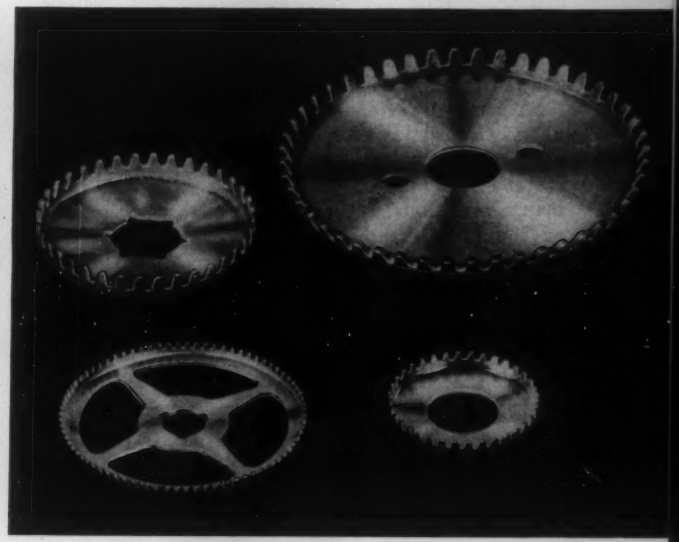


Fig. 10—Crown gears afford an inexpensive method of changing plane of rotation and simplify many design problems. Courtesy Winzeler Mfg. and Tool Co.

with any kind of holes, cutouts or irregular profiles or nontoothed portions desired, Fig. 1. Backlash-spring windows, commonly employed in instrument gears, are produced without additional operations. Thickness of the gear is limited to the tooth width at the pitch line in most cases, so a definite relationship exists between the pitch and the maximum material thickness.

Flat gears or gear blanks may be produced on a number of different types of press tooling, depending primarily upon production requirements. Progressive dies are usually the most costly and offer the highest hourly production. However, compound dies, Fig. 2, are normally employed for stampings where concentricity between a center hole and the outside diameter is important. Compound dies, like progressive dies, produce a complete part for each press stroke. The primary difference is that on a compound die, the entire inside and outside contour is done at one time, while in a progressive die, internal holes are normally pierced first and the outside shape is blanked last. This progression of operations means that concentricity depends upon piloting from station to station within the die.

Typical flat gears are found in low-cost gear trains in nonprecision instruments, clock works, toys, etc. The possible size range is wide enough to fulfill almost any requirement. Pitch diameters may range up to 10 in. and material thickness up to ¼-in.

Gears with Hubs: Flat gears can be provided with extruded bores, or the hub may be a separate part. Extruded bores, Fig. 3, are limited to about three times the material thickness, depending upon bore diameter and material. If the required hub height is less than material thickness, the raised hub can be swaged, Fig. 4. For swaging, the gear is normally produced from material slightly thicker than the final desired tooth width and the excess material is cold forged to form the embossed hub.

Composite construction, Fig. 5, can join a stamped gear to a hub, shaft, pinion, or other part. Any of a number of joining methods may be employed, including mechanical fasteners, stak-

ing, welding, soldering and brazing. For very low power requirements, press-fit joints are occasionally used, although these usually need staking or some other locking means if nonrotation of the gear in relation to the hub is desired.

Mechanical fasteners are usually rivets, Fig. 6, unless the gear is designed so that it may be readily removed from its hub; in this case, threaded fasteners should be used. Staking, Fig. 7, takes many variations, although in each case the gear or the hub, usually the latter, is deformed in a die to lock the two units together. Arc welding is reserved for larger assemblies, but projection welding, Fig. 8, is widely employed. Nonferrous gear assemblies are usually soldered or brazed, Fig. 9.

Table 1—ASME Commercial Gears, Class 4

Specification	Tolerance, TIR (in.)
Center distance composite error, total	0.0015
Composite error, tooth to tooth	0.0007
Backlash in mating gears	0.004 to 0.006
Runout, OD with bore, DP 20 to 39	0.003
DP 40 to 79	0.002
DP 80 and finer	0.001

Table 2—Typical Die Clearance

Material	Per Side (per cent of t)
Aluminum alloys 1100 and 5052	4.5
Aluminum alloys 2024 and 6061	6.0
Brass, all tempers	6.0
Cold-rolled steel, dead soft	6.0
Stainless steel, soft	6.0
Cold-rolled steel, half hard	7.5
Stainless steel, half and full hard	7.5

Crown Gears: When two mating gears are not in the same plane, stamped gears can be designed to serve the same purpose as bevel or face gears in conventional gear design, Fig. 10. Such gears are produced by cupping or flanging the edge of the blank, including the gear teeth. These gears are normally produced by first stamping a flat blank with a special developed tooth shape. After crowning, the tooth shape is standard form. Normal angles of crowning are 60 and 90 degrees.

A variation of drawing can be used for internal gear designs. The gear, Fig. 11, is made in two pieces, one piece for the internal gear and the other for the back. The two may be joined by brazing, staking or the other normal joining methods.

Gears can be designed for heavy loads where the necessary material thickness is too great for the desired pitch by using laminated construction, Fig. 12. Any desired face width may be specified by increasing the number of laminations. Exact alignment of the teeth is provided by half extrusions, dimples, or holes and dowel pins, Fig. 13. The laminations are permanently joined by employing rivets, welding or brazing.

Stamped Gear Teeth: Press operations alone can produce gear teeth to ASME commercial Class 4 limits, Table 1, with shaving. Shaving operations

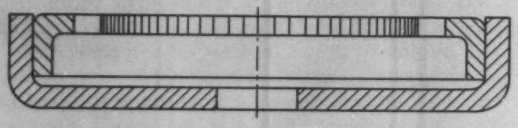


Fig. 11—Above—Internal gears may be designed for stamping. The gear is made in two parts, the internal gear itself, and a separate back. A variety of joining methods may be employed.

Fig. 12—Below—Gears for heavier loads may be designed by laminating two or more to obtain the desired face width. Courtesy Winzeler Mfg. and Tool Co.

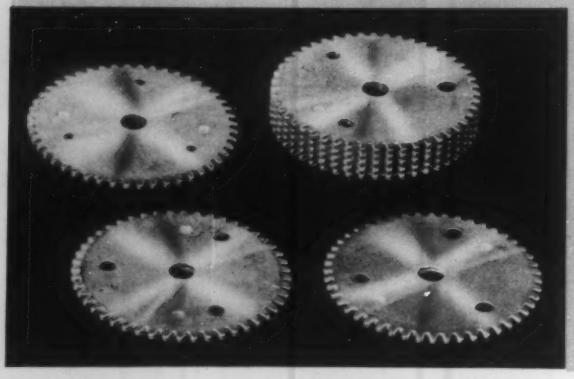
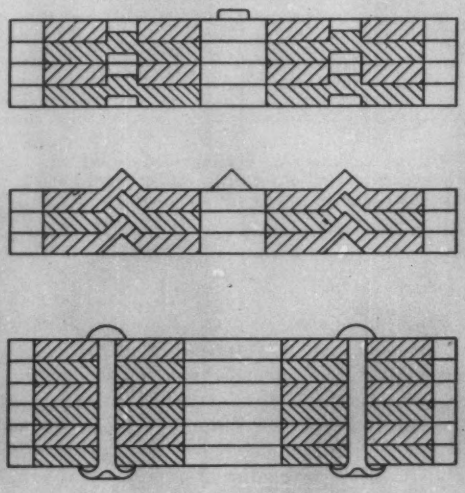


Fig. 13—Below—In laminated construction, half extrusions, dimples or dowel pins assure tooth alignment. Joining is usually by rivets, welding or brazing.



produce much closer tolerances than stamping alone, with finishes to 64 microinches rms, but the tooling is expensive. It must be remembered that although the size and shape of a stamped tooth form will change very little throughout the life of the die, the sheared edge of a stamping is neither smooth nor square, Fig. 14. If the dies are maintained in good condition, about ⅓ to ½ of the material thickness will be the exact size of the female die opening. This surface will be quite smooth; the rest of the surface will be rough and tapered to the size of the male punch. Since punch and die clearance for steel averages 7 per cent of material thickness per side, each individual tooth thickness will vary about 15 per cent of the material thickness, side to side of the tooth face at the pitch line. Table 2 gives representative die clearances for various materials. If these dimensional variations do not fulfill design requirements, the teeth can be die shaved to provide about 90 per cent smooth face, or the gear can be stamped as a blank and the teeth machined in afterward. Conventional gear-machining methods are then used, such as hobbing, shaper-generating, milling, broaching, etc.

Swaging will produce nearly full-face gears to extremely close tolerances, but the tooling is expensive and subject to rapid wearing. Swaging is most useful when design configurations are required that can not be economically produced by other methods. These configurations can include hubs, as mentioned before, local thickening at the rim, shrouding on one side of the teeth, etc., Fig. 15.

Stamped gears should be considered whenever low-cost or lightweight gears are required for high-volume applications. Tooth faces are neither regular nor high precision, but if volume justifies the tooling, tooth forms can be produced to tolerances comparable with cut teeth.

ACKNOWLEDGEMENT

This article is based partially on data made available through the co-operation of the Winzeler Manufacturing and Tool Co., Chicago, Ill.

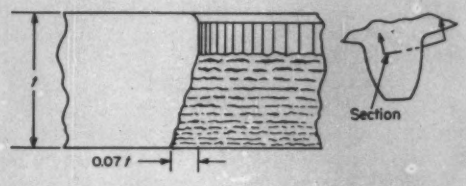


Fig. 14—Stamping does not produce a smooth tooth face. The sheared edge is to size and fairly smooth for approximately 1/3 t, then tapers back with a somewhat ragged surface. This surface condition can be corrected by shaving, but the shaving die is expensive.

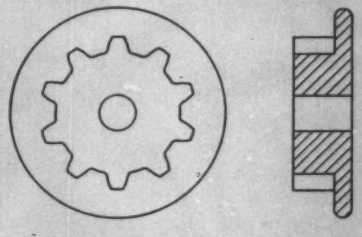


Fig. 15—Swaging, although requiring expensive tooling, can be used to produce unusual design requirements. Swaging, a type of cold forging, can be used to force a part into a die cavity for high precision and good finish, or to produce features such as the half shroud shown.

Tips and Techniques

Resistance Calculations

The resistance equivalent to that of two resistors in parallel, or of two capacitors in series, is given by

$$\frac{1}{R_t} = \frac{1}{R_a} + \frac{1}{R_b}$$

where R_t = equivalent resistance of the network; and R_a and R_b are individual resistances.

This law of combination holds for a number of other quantities also. The equation is usually written in the form

$$R_t = \frac{R_a R_b}{R_a + R_b}$$

An alternative form can be obtained by dividing both numerator and denominator by R_b (assuming $R_b > R_a$). Then,

$$R_t = \frac{R_a}{1 + R_a/R_b}$$

Thus, R_t is always less than R_a (the lower-valued resistor) and the amount by which it is less can be easily estimated from the ratio R_a/R_b. This form also lends itself to simple slide-rule calculations. If R_b on the C scale is set opposite R_a on the D scale, R_a/R_b (a quantity between 0 and 1) appears under the C-scale index. The C-scale index is then moved to this value plus one, on the D scale. Then, over R_a on the D scale, R_t is read from the C scale.

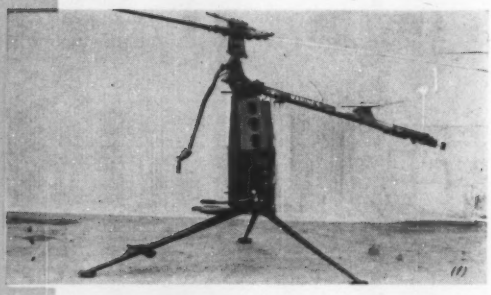
In similar fashion, one can determine the resistance R_b that must parallel R_a to obtain a given R_t from the expression

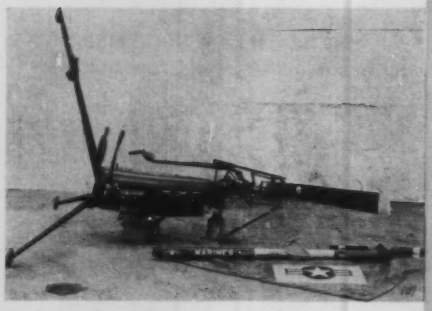
$$R_b = \frac{R_t}{1 - R_t/R_a}$$

This adapts itself for both quick estimation and for simple slide-rule calculation.—JESSE E. ROTH JR., *electrical engineer, Otis Elevator Co., Electronic Div., Brooklyn, N. Y.*

Design Guide Pin

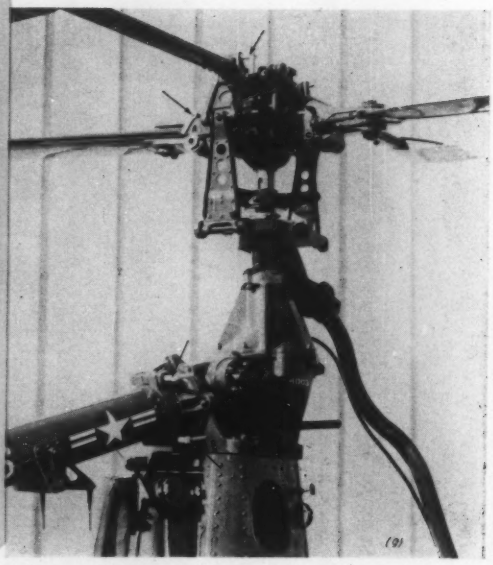
By LEO F. SPECTOR
Associate Editor
MACHINE DESIGN





A one-man helicopter, the Hiller XROE-1 Rotorcycle, utilizes a number of strategically located single-acting quick-release pins to achieve complete "foldability." Progressive stages in the assembly of this unique design are shown in Fig.b through f. A close-up view of some of the assembly details appears in Fig. g. Developed for the Marines, this small helicopter weighs 270 lb; is powered by a Nelson two-cycle, four-cylinder, horizontally opposed, air-cooled engine rated at 40 bhp/4000 rpm. It has a maximum speed of 70 mph and a working range of about 170 miles. The complete assembly folds into a compact package that can be easily transported from point to point or air dropped to personnel.

Photos, courtesy Hiller Helicopters



Fasteners

Part 2—Quick-Release Attachment

- **Basic Forms**
- **Selection Factors**
- **Design Practices**
- **Production Considerations**

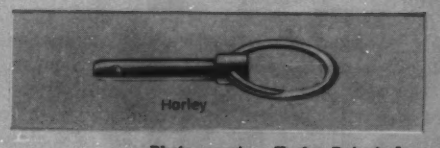
SIMILAR in form but different in details of construction and application, pin fasteners can be adapted to a wide range of assembly requirements where loading is primarily in shear. From a design standpoint, two specific fastening functions are offered by the various types of pin devices: 1. Semipermanent assembly. 2. Quick-release attachment.

Pin fasteners for semipermanent assembly were covered in detail in a previous article (November 14 issue, Pages 122-131). In this second article attention will be given to the various quick-release pin types and the factors influencing their selection and application in specific design situations.

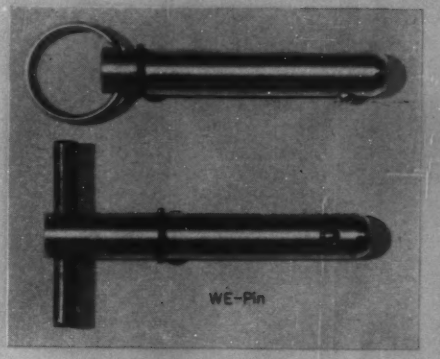
Several commercial pin devices have been developed for rapid, or frequent, manual assembly and disassembly. Except for one quick-release "cotter pin," these pin designs are based largely on aircraft requirements and have seen wide use in the assembly and installation of ground-handling and airborne equipment for both fixed and rotary-wing aircraft. However, applications in both industrial and domestic equipment are growing more common in a wide range of light and heavy-duty assembly functions.

Typical possibilities are graphically demonstrated in the accompanying illustrations of a "collapsible" helicopter design which utilizes a large number of quick-release pins to effect complete assembly or disassembly of the aircraft structure.

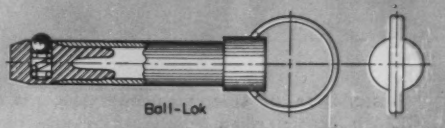
A self-contained fastening device, the quick-release pin represents the result of combining a standard pin form with some type of manually operated locking mechanism. Certain practical advantages in ease and convenience of assembly and



Photo, courtesy Harley Patents Inc.

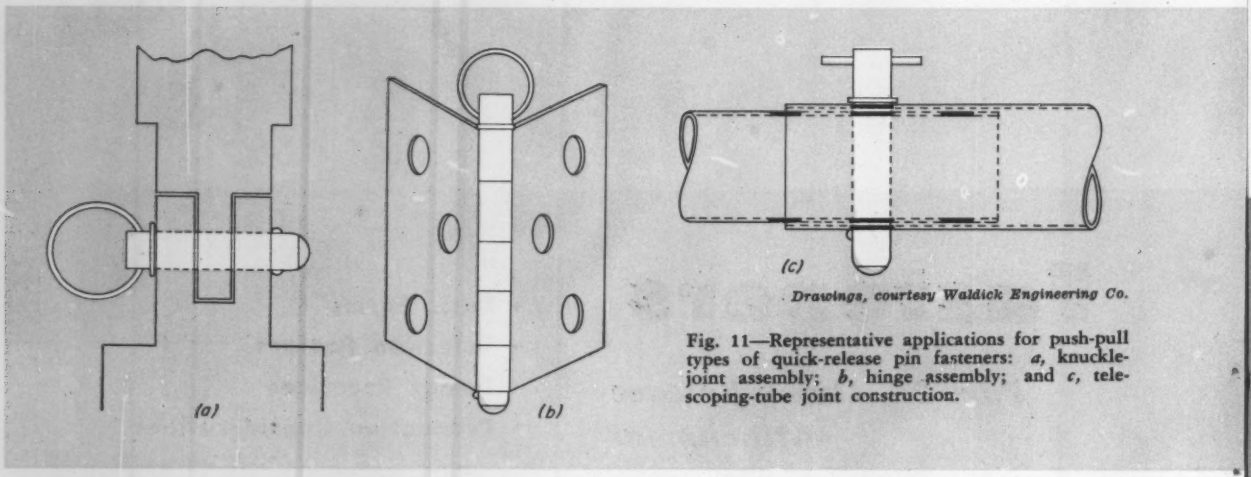


Photo, courtesy Waldick Engineering Co.



Drawing, courtesy D. W. Price Corp.

Fig. 10—Typical commercial quick-release pin designs of the push-pull type. Core of detent assembly may be either a spring, as shown in the cross-section view, or some other resilient means.



Drawings, courtesy Waldick Engineering Co.

Fig. 11—Representative applications for push-pull types of quick-release pin fasteners: *a*, knuckle-joint assembly; *b*, hinge assembly; and *c*, telescoping-tube joint construction.

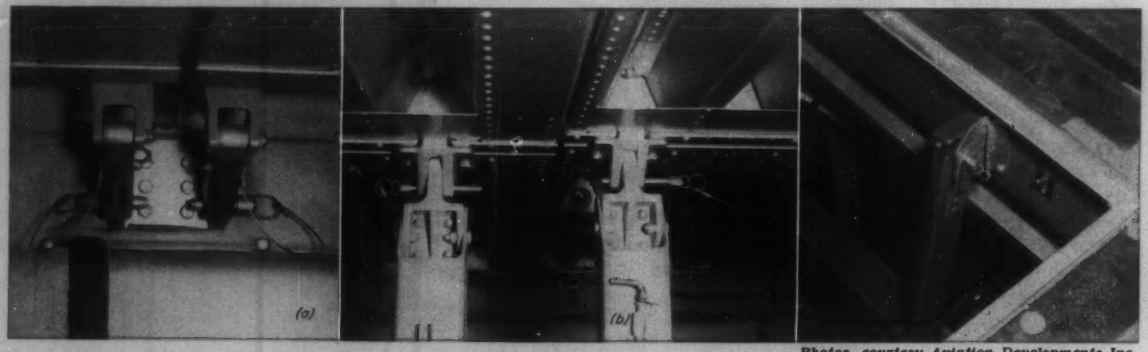
disassembly are achieved through the design, although unit costs of these pin devices will generally run higher than for other fasteners because of the more elaborate construction involved.

In contrast to the majority of semipermanent pin fasteners which require a "force-fit" assembly, quick-release pins are designed for a clearance fit in holes formed to nominal-diameter dimensions. Holes drilled to normal production tolerances are generally considered adequate; however, manufacturing and accuracy requirements may influence the degree of precision necessary.

Commercially available quick-release pins vary widely in head styles, types of locking and release mechanisms, and range of pin lengths. Unlike the semipermanent-assembly pins, these fasteners are not presently covered by any formal standards, although the possibilities of a standardization program are now being studied in the aircraft industry. However, established manufacturing practices for the various commercial pin devices are generally considered adequate for design applications as related to pin tolerances and strength, and reliability of locking devices.

Quick-release pin fasteners are of two basic types: 1. Push-pull. 2. Positive locking. Pins of the first type employ a retaining mechanism that is actuated by manually overcoming resistance to insertion or removal. For the second type, operation of the locking mechanism is independently controlled. Each of these general types will be considered separately.

Push-Pull Pins: Representative quick-release pins of the push-pull type are shown in Fig. 10. These pins are made with either a solid or hollow shank, containing a detent assembly in the form of a locking lug, button, or ball backed up by



Photos, courtesy Aviation Developments Inc.

Installation of complete upper deck in Douglas C124 is accomplished with quick-release pin fasteners. Knuckle-joint arrangement, a, anchors half of floor structure to side of fuselage. Similar construction, b, holds center supports in place. These supports can be quickly removed, allowing each half of floor to drop against sides of fuselage to facilitate the cartage of "tall" equipment. Access to upper deck is provided by detachable metal-ladder assembly, c, that is anchored with quick-release pins.

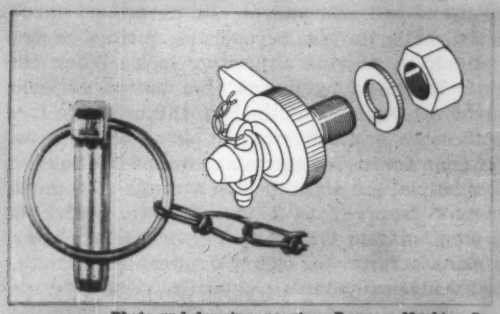


Photo and drawing, courtesy Danneer Machine Co.

Fig. 12—Heavy-duty, positive-locking, quick-release cotter pin. When the pin is inserted, the ring is folded down to lock the pin securely in position.

some type of resilient core or plug. The detent member projects from the surface of the pin body until sufficient force is applied in assembly or removal to cause it to retract against the spring action of the resilient core and release the pin for movement.

Common commercial pin sizes offer a range of nominal diameters from 3/16 to 1¼ in. (1/16-in. steps) in grip lengths from ½ to 4 in. (0.1-in. steps). Pin materials include standard screw-machine stock, Leadloy, and low-carbon, stainless, and heat-treated alloy steels. In addition, custom pins made to special size, material or shape requirements can be obtained from manufacturers.

These pins are normally supplied with a pull-ring mounted in the head section, although other grip designs, such as T and L-shaped handles, are available. Rated pull-out loads (force required to actuate detent) vary with manufacturers but can be regulated within limits to meet specific assembly requirements. Normal range is 10 to 30 lb, depending on pin size; however, ratings from 5 to 50 lb are possible. A value of about 10 lb is generally considered adequate for most design situations.

Typical applications for pins of the push-pull type are shown in Fig. 11. These pins are made 0.002 to 0.004-in. undersize to fit any standard hole drilled to nominal-diameter dimensions. From an operational viewpoint, holes up to 0.010-in. oversize are permissible; however, pull-out loads can be expected to decrease as looseness of fit increases. To facilitate assembly of the pin, hole edges should be deburred or slightly chamfered.

Primary function of these pins is to fasten parts under shear loading. Ideally, direction of load application should be at right angles to the shank of the pin. Locking mechanisms of these pins are designed to provide secure retention against accidental disassembly due to vibration or the force of pin weight. But they are not recommended for application under tension loading.

Shear strength of the pin is a function of the pin material. For pins of high-alloy steel, heat treated to a tensile strength of 125,000 psi, load capacity in single shear varies from about 3700 lb for ¼-in. size to about 59,000 lb for 1-in. size.

In the specification and application of push-pull types of quick-release pins in mechanical assemblies, here are some practical points to be kept in mind in design:

1. To prevent pins from being lost or mislaid, or from falling into the operating assembly and becoming lodged, some means of anchoring the pin near the point of application should be provided. For example, a short length of cable, chain or wire can be employed to fasten the pull grip or handle to a main structural member, allowing sufficient slack to permit free movement of the pin in assembly and disassembly.

2. If pin assemblies are to be exposed to severe environmental conditions (temperature, moisture, etc.), consideration should be given to the possibility of jamming due to freezing or expansion of the pin and its mating parts. In some instances, pretesting of prototype assemblies under simulated operating conditions may be justified where reliability is a critical factor.

3. In rotating assemblies, pull-out load developed by the pin should be sufficient to withstand the effect of any centrifugal forces produced. Otherwise, the pin may creep out of its hole, unlocking the assembly.

4. Location of the pin assembly should permit easy pin removal by a quick pulling motion with one hand. High pull-out load requirements in cramped space can lead to problems in assembly and disassembly, and should be avoided.

Positive-Locking Pins: Three types of quick-release pin fasteners have been developed in which the locking action is independent of insertion and removal forces. One is the heavy-duty cotter-pin design mentioned previously. The other two types are the various single-acting and double-acting pin devices.

As in the case of the push-pull pins, these pins are primarily suited for application under shear loading. However, some degree of tensional loading usually can be tolerated without affecting the pin function. As a general rule, construction of these pins is more elaborate than for the push-pull types.

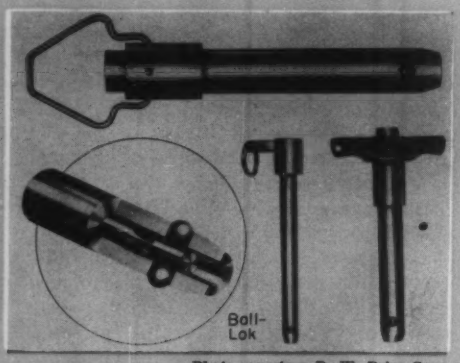
HEAVY-DUTY COTTER PIN: Developed for heavy-duty fastening service in agricultural equipment, this quick-release pin, Fig. 12, employs a forged high-carbon steel body to replace the conventional split-cotter construction. Locking action is provided by a tempered steel snap ring mounted to the head of the pin. In assembly the ring folds over the end of the shaft, or similar member, in which the pin is assembled.

Design options include round and semiround (flat on back side) pins. The round pin has a nominal diameter of ¼ in. and a shank length of 1¾ in. Semiround pins, with a nominal diameter of 7/16-in., are available in shank lengths of 1-

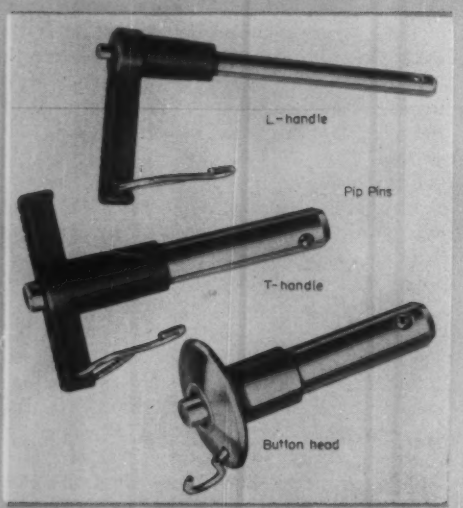
7/16 and 1¾ in. Two snap-ring sizes are furnished: 1⅜ and 1⅝ in. diameters. The snap rings are wound with a slight spiral to keep them firmly folded against the pin in the locked position. Pin assemblies can be obtained with a length of sash chain attached for anchoring to the machine structure.

Simple but rugged fastening elements, these pins have seen wide use in the attachment of tractor hitch assemblies. They have also been employed in door latches or as a means for anchoring pivoted or hinged machine members.

SINGLE-ACTING PINS: Representative types of single-acting pins are shown in Fig. 13. Similar in appearance, and in certain aspects of application, to the push-pull pins discussed previously, these quick-release fasteners are basically an aircraft development.



Photo, courtesy D. W. Price Corp.



Photo, courtesy Aviation Developments Inc.

Fig. 13—Typical commercial designs of single-acting, quick-release pin fasteners. Locking action of pin is controlled by means of manually operated spring-located plunger-and-ball mechanism.

Locking action is controlled by a spring-located plunger-and-ball mechanism. In normal (locked) position, balls project beyond the surface of the pin shank to provide a positive lock. When the plunger is moved by means of a button or lever assembly at one end of the pin, the balls are free to sink below or flush with the pin surface, releasing the pin for movement in and out of the hole.

Commercial pin sizes include a range of nominal diameters from ¼ to 1 in. (1/16-in. steps) in grip lengths from 0.1 in. up (⅛ or 0.1-in. steps). One manufacturer, for example, offers grip lengths up to 9.9 in. as standard.

A number of head styles and release mechanisms have been developed for these pins. Conventional forms include button-head, T-handle, and L-handle designs, Fig. 13, with a pushbutton release. The button-head construction is recommended for general-purpose application and offers advantages from an appearance standpoint. The T and L-handle designs are recommended where binding in assembly is possible and may require a firm grip and twisting motion for disassembly. Pull-release types, as well as combination push-pull units, for remote operation or other special assembly requirements can also be obtained.

All of these pins are made undersize (from 0.0015 to 0.0045 in. depending on manufacturer) for a free fit in holes drilled to nominal-diameter

Photos, courtesy Aviation Developments Inc.

Fig. 14—Conventional double-acting, quick-release pin fastener showing construction details and typical application in Lockheed T2V-1 dive-brake assembly. Used for direct connection of hydraulic actuator and dive-brake crank horn, pin provides positive locking action but can be readily driven in or out of fixture for quick removal and assembly under tactical operations.

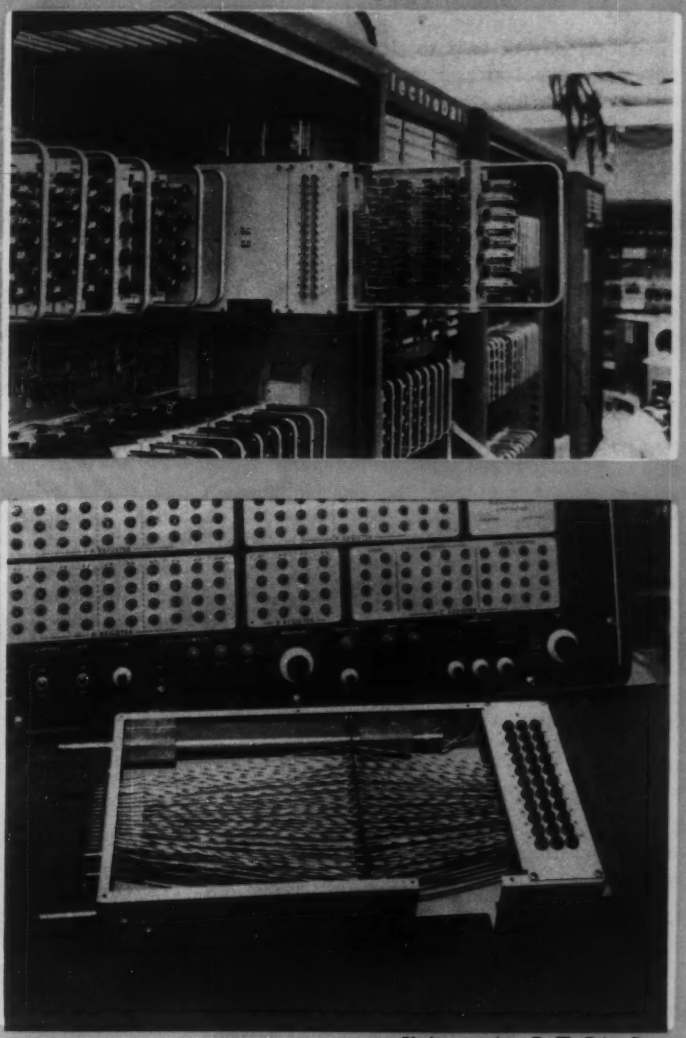
dimensions. Potential applications parallel those of the push-pull pin devices, Fig. 11.

Minimum single-shear strength of these pins varies from about 4100 lb for the ¼-in. size to 65,300 lb for the 1-in. size. These values are based on one-half of the average double-shear failure strength determined by test. As indicated previously, in addition to primary shear strength, these pins offer limited capacity in tension. Determining consideration in such applications will be either the strength in bearing of the part material in contact with the locking balls, or the shear strength of the balls at the plane of loading, whichever is the lower. Quality of fit, nature of loads, and required reliability of the assembly are all contributing factors that must be evaluated. Where tensile load is critical, special pin designs with four locking balls for maximum tensile strength can be obtained.

In the specification and application of single-acting pins, some of the practical points discussed previously for the push-pull types should be kept in mind. These are, namely: Method of anchoring pin to structure, effect of environmental conditions, and accessibility of pin assembly.

DOUBLE-ACTING PINS: A modification of the single-acting type, these pins, Fig. 14, have a bidirectional spring-located plunger, That is, movement of the plunger in either direction along its barrel will release the locking balls.

Conventional form of this pin has a pull-ring at the head end with the tip of the plunger extending beyond the other end of the pin. An intentional blow on the protruding head or tip shifts



Testing of individual circuit "books," or modules, in the Datatron electronic digital computer is facilitated by a special extender unit. Mounted between the circuit book and computer chassis, the extender unit moves the circuit into an easily accessible position and provides a battery of plug-in test points for analysis of circuit components. The extender unit is mounted in place by a guide prong at the bottom and a long single-acting quick-release pin at the top of the extender unit. Purpose of the pin is to furnish a firm cantilever support for the test assembly as well as to provide a means for quick installation and removal of the extender unit. Movement of the pin in assembly is prevented by two snap rings mounted in grooves in the pin body. Access to the push-button release mechanism of the pin is provided by a hole in the top of the extender-unit sheet-metal casing.

Photos, courtesy D. W. Price Corp.

the plunger, releasing the balls and permitting the pin to be driven in or out of the hole. In addition, direct manual removal of the pin may be accomplished by means of the pull ring.

Commercial size and material specifications for these pins are essentially the same as for the single-acting types except for one detail. Minimum grip lengths vary from 0.20 in. in the ¼-in. size to 0.9 in. in the 1-in. size.

General range of application of the double-acting pins is, by and large, the same as for the single-acting types with one qualification. These pins are recommended primarily for use where normal structural distortion, or other loads on joint and pin, can cause hole misalignment and binding problems. Under such conditions, the drive-in, drive-out feature of these pins offers practical advantages in assembly and disassembly.

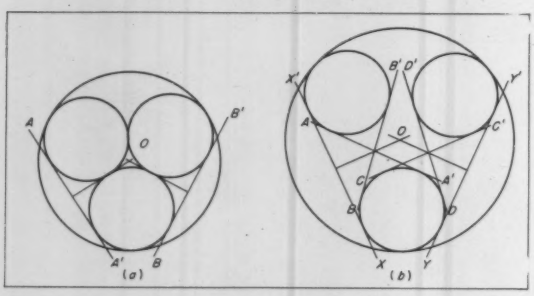
EDITOR'S NOTE

On behalf of the National Aircraft Standards Committee, a preliminary survey to evaluate all of the various types of pins used in the aircraft/rotorcraft industry has been completed by Hiller Helicopters' NASC representative: J. Edward Kampf, Supervisor, Engineering Standards and Procedures, Hiller Helicopters, Palo Alto, Calif. Studies are now underway to standardize these types of fasteners through a series of NAS drawings. Any additional information, comments, or suggestions that may be of help in this effort will be welcomed by Mr. Kampf.

Tips and Techniques

Circumscribing Circles

Two methods may be used to circumscribe a circle about three equal circles when the centers of the given circles are not known.



Tangent Circles (*a*);

1. Draw tangents *AA'* and *BB'*
2. Erect perpendiculars from the tangent lines, passing through contact points of the respective circles.
3. Intersection *O*, of these perpendiculars is the center of the circumscribing circle.

Nontangent Circles (*b*);

1. Draw crossing tangents *AA'*, *BB'*, *CC'*, and *DD'*.
2. Draw outside tangents, *XX'* and *YY'*.
3. Erect perpendiculars from *XX'* and *YY'*, passing through the intersections of lines *AA'*, *BB'*, and *CC'*, *DD'* respectively.
4. Intersection, *O*, of these perpendiculars is the center of the circumscribing cycle.

—C. G. ROY, *technical assistant, Indian Institute of Technology, Mechanical Engineering Dept., Kharagpur, India.*

Accurate Circle Computations

Multiples and reciprocals of pi are convenient for computing circumferences and diameters of circles. Practically any desired degree of accuracy can be obtained, and since the only operation performed is addition, it is easy to check the results.

Table 1—Multiples and Reciprocals of Pi

Integer N	Multiple πN	Reciprocal N/π
1	3.14 159 265	0.31 831
2	6.28 318 531	0.63 662
3	9.42 477 796	0.95 493
4	12.56 637 061	1.27 324
5	15.70 796 327	1.59 155
6	18.84 955 592	1.90 986
7	21.99 114 857	2.22 817
8	25.13 274 123	2.54 648
9	28.27 433 388	2.86 479

As an example of the use of the table, the circumference of a circle of 28.153 diameter, correct to three decimal places, is

$$\begin{aligned} 20\pi &= 62.8318 \\ 8\pi &= 25.1327 \\ 0.1\pi &= 0.3141 \\ 0.05\pi &= 0.1571 \\ 0.003\pi &= 0.0095 \\ \hline & 88.4452, \text{ or} \end{aligned}$$

88.445 to three decimal places

The diameter corresponding to a circumference of 28.153, correct to three decimal places, is

$$\begin{aligned} 20/\pi &= 6.3662 \\ 8/\pi &= 2.5465 \\ 0.1/\pi &= 0.0318 \\ 0.05/\pi &= 0.0159 \\ 0.003/\pi &= 0.0009 \\ \hline & 8.9613, \text{ or} \end{aligned}$$

8.961 to three decimal places.

The value of $\pi = 3.1415926536$ was used for obtaining the multiples of pi and the values then rounded off to eight decimal places; 0.3183099 was used for the reciprocal of pi and the computed values rounded off to five decimal places.—F. MURRAY, *Chicago, Ill.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Chart for finding Kinematic Viscosity and Reynolds Number

By KENNETH A. MERZ
Assistant Chief Engineer
Air Impeller Div.
Torrington Mfg. Co.
Torrington, Conn.

FAN and blower systems for cooling airborne electronic equipment are usually more difficult to design than sea-level systems because of the changed physical characteristics of air as a heat-transfer medium at high altitudes. Space for air flow in aircraft is limited, and air density is low. Therefore, air is usually delivered at extremely high velocities in order to remove a given quantity of heat from power tubes, transformers, or other electronic components which produce high temperatures.

Two basic characteristics of air if known for a particular airborne cooling system allow determination of the heat-transfer film coefficient: 1. Kinematic viscosity, ν. 2. Reynolds number, N_R. Kinematic viscosity is the ratio of absolute viscosity, μ, to fluid density, ρ. Since absolute viscosity rises with temperature and density drops with decreasing pressure (high altitudes), kinematic viscosity can be extremely high in airborne cooling systems. The significant pressure, of course, is that maintained in the actual cooling section.

Reynolds number is a dimensionless measure of air-flow condition given by the expressions

$$N_R = \frac{2Q}{\nu(\pi r)} \quad \text{(round duct)}$$

and

$$N_R = \frac{2Q}{\nu(a+b)} \quad \text{(rectangular duct)}$$

where Q is air flow rate, a and b are side dimensions of a rectangular duct, and r is the radius of a circular duct or flow path.

The chart in Fig. 1 gives kinematic viscosity as a function of temperature in the heat-transfer area for various altitudes in the electronic section from sea-level to 100,000 ft. Reynolds number is given at values above 30,000 for turbulent flow only. It is not likely to be lower in airborne applications and can be obtained from the known kinematic viscosity, required flow rate Q, and duct or flow path dimensions, whether rectangular or round.

Example: In the example illustrated in Fig. 1, values of kinematic viscosity and Reynolds number are desired for an air temperature of 200 F, altitude of 60,000 ft, flow rate of 500 cfm, and a 3 x 4-in. rectangular duct. A vertical line from 200 F on the temperature scale intersects the curve for 60,000 ft at point A. A horizontal line from point A intersects the viscosity scale at 35×10^{-4} sq ft per sec. A line from this point through 500 on the flow-rate scale meets the reference line at point B. Finally, a line from point B through 7 on the scale for rectangular ducts (equivalent to a round duct with a 2¼-in. radius) intersects the Reynolds number scale at about 500,000.

Nomenclature

a	= Side dimension of rectangular duct, in.
b	= Side dimension of rectangular duct, in.
N_R	= Reynolds number
Q	= Air flow rate, cfm
r	= Radius of circular duct, in.
μ	= Absolute viscosity, lb per ft-sec
ν	= Kinematic viscosity, sq ft per sec
ρ	= Fluid density, lb per cu ft

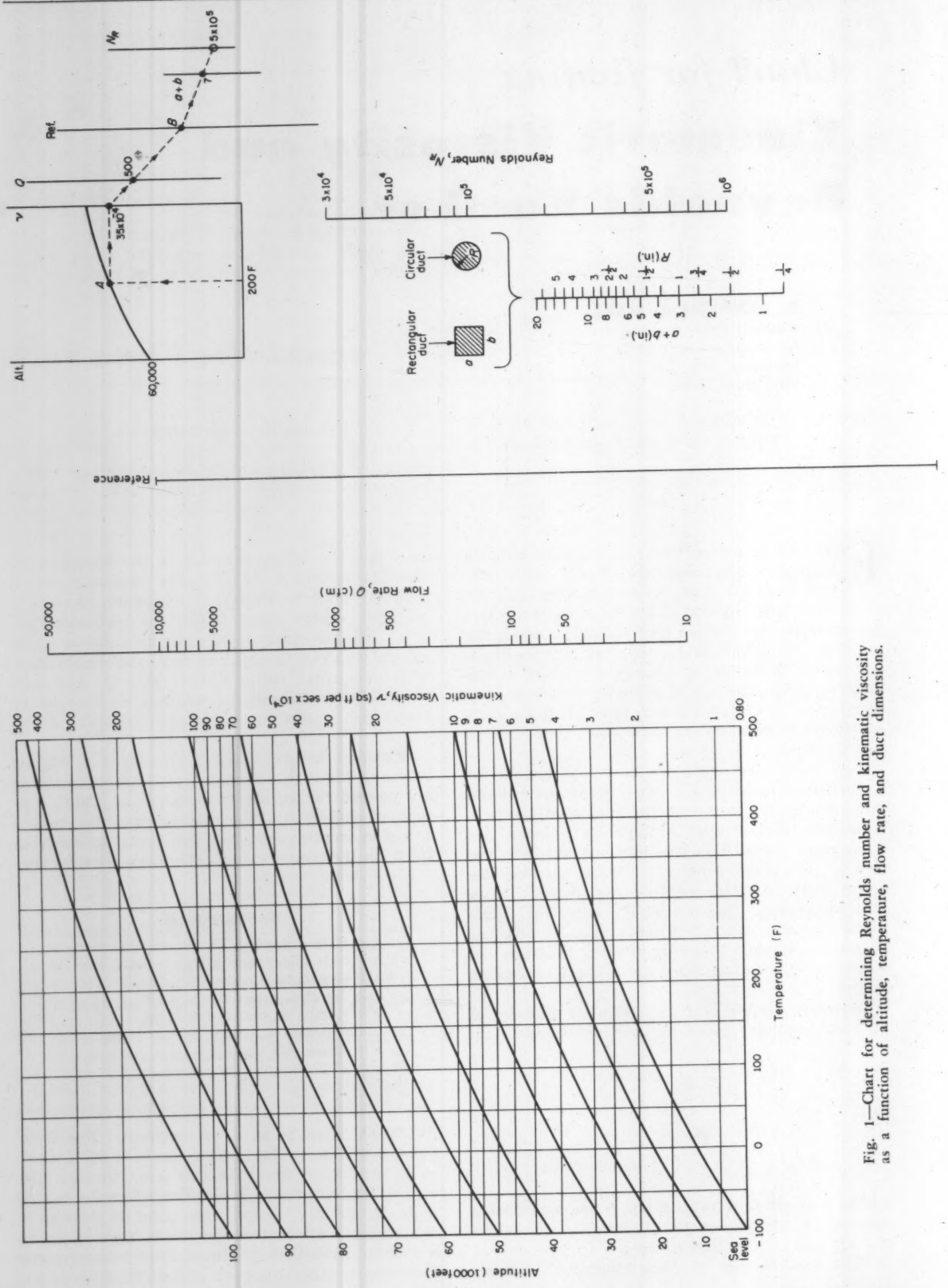


Fig. 1—Chart for determining Reynolds number and kinematic viscosity as a function of altitude, temperature, flow rate, and duct dimensions.

Properties of Cellular Plastics

By LEON TALALAY
Director of Research and Development
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NEW cellular plastic materials in rigid and flexible form make it possible to design a large number of products to perform specific functions. In the past, cellular materials based on rubber had a relatively fixed range of properties and were not as adaptable to specific applications.

Flexible Cellular Materials

Rubber, vinyl, and urethane are the major contenders in the field of flexible cellular materials. Fig. 1 shows the relative stress-strain relationship of four materials: Rubber foam, vinyl foam, and two types of urethane foam.

The curve for an early polyester urethane foam, Type 1, shows a characteristic discontinuity which makes it an undesirable material for certain applications such as comfort cushioning. Resistance to compression builds up rapidly, then changes at a certain level of deflection. Polyurethane foam, Type 2, however, shows more desirable stress-strain characteristics since it has a much lower density for the same compression-load carrying capacity and is based on inexpensive raw materials.

Shock Absorption: Fig. 2 shows hysteresis observed on loading and unloading the four types of materials under discussion. Data were obtained at a rate of 10 in. per min and materials were compressed by 75 per cent of their original height. Polyester type of urethane exhibits remarkable properties of shock and energy absorption. The others, particularly rubber foams, have too little hysteresis loss to be good shock absorbing materials. The faster the rate of loading, the greater the hysteresis loop becomes with urethane, while little change is observed with rubber.

Rebound elasticity of the various materials is a relevant fact in shock protection. In addition to being able to absorb the energy

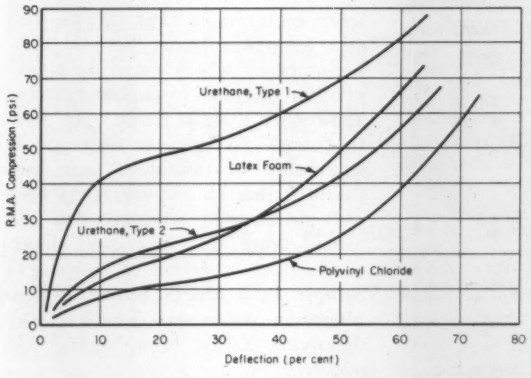


Fig. 1—Compression-deflection curves for rubber foam, vinyl foam, and two types of urethane foam. The curve for polyester urethane foam, Type 1, shows a characteristic discontinuity which makes the material undesirable for certain applications. Polyurethane foam, Type 2, has a much lower density for the same compression-load carrying capacity.

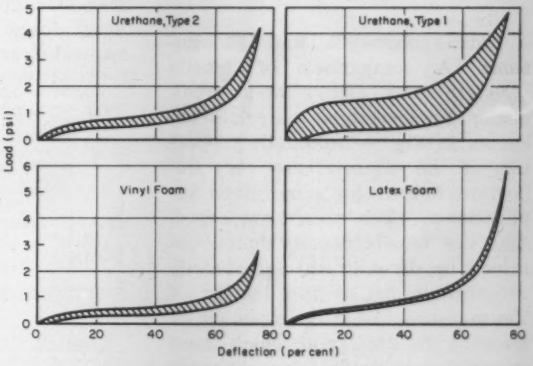


Fig. 2—Hysteresis loops observed on loading and unloading rubber, vinyl, and urethane foams. Materials were compressed by 75 per cent of their original height. Rubber foams have too little hysteresis loss to be used in applications requiring good shock absorbing properties.

of shock, the material, for proper protection, should have relatively little rebound elasticity. Urethane polyester foam, Type 1, has the lowest rebound elasticity of the flexible materials under consideration, although vinyl foam is a close second. Rebound elasticity of polyester urethane is about 30 per cent as compared to 75 per cent for natural latex foam rubber.

Sound Absorption: Fig. 3 shows absorption coefficients of three soft and one rigid cellular material at various frequencies. All materials are quite good in the range of medium frequency vibrations. Data for the rigid polystyrene foam seem to indicate that it is not too satisfactory a material. However, good results have been obtained in noise level reduction through the use of rigid cellular plastic panels having a pattern of perforations.

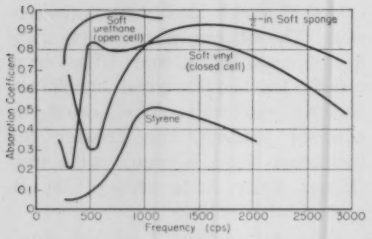


Fig. 3—Sound absorption coefficients of three soft and one rigid cellular material at various frequencies. Despite the low coefficient of absorption for rigid styrene foam, satisfactory results were obtained in noise-level reduction tests with perforated styrene panels.

Tensile Strength and Elongation: A comparison of tensile strength and elongation-at-break of the various cellular materials are shown in Fig. 4. Strength properties of the material are very important factors for some given applications. The open bars represent the tensile/density index obtained by dividing absolute tensile strength in psi by the density of the material tested in lb per cu in. Because the density at which these materials are made for a different load-carrying service might be widely different, the tensile/density index is a truer expression of the comparative strength of these cellular plastic materials.

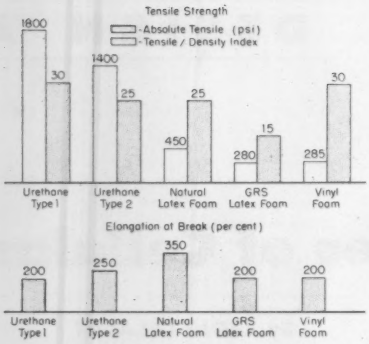


Fig. 4—Comparison of tensile strength and elongation-at-break of various cellular materials. The tensile/density index, represented by the open bars, is a truer expression of comparative strengths of these materials than values shown for absolute tensile strength.

Urethane Type 1 and Type 2 are considerably superior to both natural and synthetic rubber foam and to vinyl, taking into account its higher density. This is also true of abrasion resistance, although no good means of measurement has yet been found for this property.

Elongation-at-break is rather similar for most cellular materials. However, natural-rubber foam has an elongation-at-break of 350 per cent or more although, generally speaking, this property is not too important because most cellular materials are used in compression.

Tear Strength: Fig. 5 shows a rather more significant difference between rubber and cellular plastic materials as found in the property of tear resistance. Plastic cellular materials are vastly superior in tear strength to rubber foam, and vinyl foam appears to have the highest tear resistance.

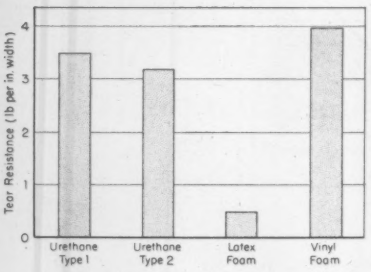


Fig. 5—Relative tear resistance of rubber and cellular plastic materials. The plastic foams are greatly superior in tear strength to rubber foam.

Flexing Properties: Ability of a cellular material to withstand repeated compression deformation is shown in Fig. 6. Softening or compression loss of the various materials is shown for two rates of flexing. One is low-speed flexing at 1 cps and the other is high-speed flexing at 25 cps. Here, the picture does not look quite as good for the cellular plastic materials. Also, significance of the high-speed flexing test is not yet clear. High-speed flexing data apply only to transportation seating, aircraft, etc. at this time. Of the cellular plastic materials, the polyether type urethane is best.

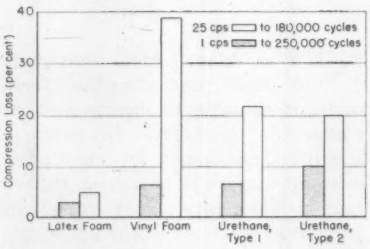


Fig. 6—Softening or compression loss of plastic and rubber cellular materials. Low-speed flexing was carried to 250,000 cycles at a deflection of 50 per cent of the original material height. High-speed flexing was carried to 180,000 cycles at a 25 per cent deflection. Loss of hardness was determined after the test at 50 per cent compression.

Humid Aging: One special permanence property which has received attention recently is humid-aging performance of urethane foams. A requirement of any cellular material is that it age well on a long-term basis. Normal heat-aging tests which have been applied in the past to rubber systems show very little with cellular plastic foams. It has been observed in a number of instances that urethane foams do not stand up very well in humid atmospheres. A humid-aging test has been developed which consists of keeping a sample in a warm humid atmosphere to determine whether any depolymerization or softening has occurred.

Urethane foams of the polyester type do suffer a loss in properties when exposed to a warm humid atmosphere. The situation is greatly improved with the polyether

type of urethane, properly formulated, and it is generally agreed now that these materials will age well on a long-term basis.

Rigid Cellular Materials

Generally important properties of rigid foams are listed in Table 1. Quite a number of materials qualify as rigid cellular bodies, but the major ones are polystyrene, vinyl (frequently of the closed-cell type), and polyurethane. The others are rather special in their application and only limited amounts of them have been produced.

Most of the materials can be made in a wide range of densities, some of them amazingly low such as phenolic or urea formaldehyde foams available in densities of less than 1 lb per cu ft. Polyethylene is at the other end of the density scale in a class by itself. Strictly speaking, polyethylene is not a rigid material. One of the fundamental properties of a rigid foam material is compressive strength.

Thermal conductivity of all rigid foams is quite low and, in fact, approaches quite reasonably the thermal conductivity of still, dry air. It is for this reason that almost all of the rigid foam materials have been used for insulating purposes. There is a great difference in heat-distortion points. Some foams are distinctly thermoplastic such as polystyrene and vinyl, while others could definitely be considered as thermoset types such as epoxy, ebonite, silicone, and phenolic foams. Cellulose acetate is a somewhat intermediate material. It is thermoplastic in nature but at the same time has a very high heat-distortion point.

With regard to urethane foams, the heat distortion point is approximately 210 to 250 F but, recently, urethane foam materials have been developed which have heat-distortion points considerably higher. A material known as polymethyl-polyphenol isocyanate is claimed to have a distortion point of 500 F.

Amount of water absorption distinguishes the closed-cell type from the open-cell type of foam, Table 1. Some of these foams, especially the closed-cell vinyls, are excellent for floatation applications. In general, while rigid foams have not advanced as rapidly as the flexible materials, they have an even greater potential than flexible foams. Probably their most promising future lies in their use in structural applications and as core materials for sandwich construction.

Tensile Strength: Relationship of tensile strength to density for the three major materials is shown in Fig. 7. While tensile strength of a rigid material is not necessarily the most important structural property, it is a measure of strength of the polymer used in building the cellular body. Urethane outranks the other materials because it maintains its strength up to 200 F while vinyl and styrene quickly lose theirs.

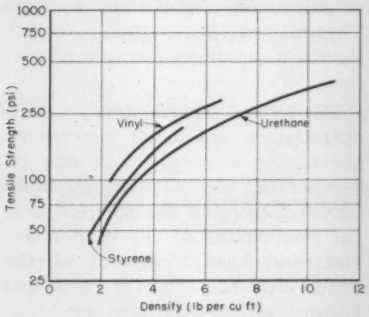


Fig. 7—Relationship of tensile strength of rigid foam to density. While not necessarily an important property, tensile strength is a measure of the strength of the polymer used in building the body of the cellular plastic material.

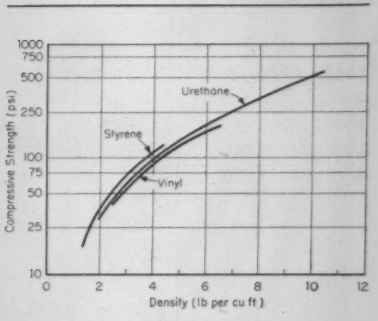


Fig. 8—Compressive strength or crush resistance of rigid cellular plastics. Compressive strength varies greatly with density and is a measure of the ability of the material to withstand load to the point at which it begins to yield.

Compressive Strength: A more fundamental measure of the structural properties of a rigid material is its compressive strength or crush resistance. Compressive strength to failure for styrene, urethane, and vinyl foams is shown in Fig. 8. In general, the materials are in the same order of magnitude regarding strength. This compression strength is a measure of the ability of the material to support load up to the point at which it begins to yield, and varies greatly with density. Again, this factor depends on temperature and is better for thermoset, cross-linked materials such as urethane.

Modulus of Elasticity: Fig. 9

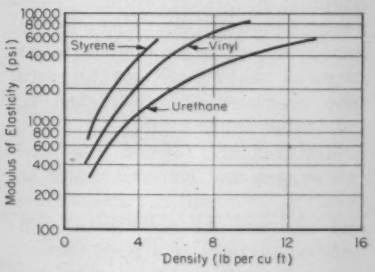


Fig. 9—Modulus of elasticity of rigid foam. This property, together with the relatively high compressive strength, makes the material suitable for use in sandwich structures.

Table 1—Properties of Rigid Foams

Type	Density (lb per cu ft)	Compressive Strength (psi)	Thermal Conductivity (btu/in./hr/sq ft/F)	Heat Distortion (F)	Water Absorption
Polystyrene	1.6– 4.5	18–140	0.25	155–175	Low
Cellulose acetate	6.0– 7.0	115–135	0.31	350	Low
Vinyl	2.0– 5.0	20–100	0.23–0.25	150	Low
Urethane	2.0–20.0	4.5–475	0.21–0.25	212–250	Moderate
Polyethylene	29	.....	.....	.....	Low
Silicone	10.0–20.0	100–475	0.31	500–700	Low
Phenolic	0.3–14.0	0–500	0.21–0.25	260–350	Moderate
Urea formaldehyde	0.75– 1.0	0–5	0.18–0.21	120	High
Epoxy	2.0–16.0	7–460	.....	300	Low
Ebonite-hycar	6.0–20.0	30–400	0.24	300	Low

probably defines the most important property of a rigid foam material. The modulus of elasticity is the property which, together with the relatively high compressive strength, enables these materials to be used in sandwich structures. Here, there is somewhat of a difference between materials. Styrene foam has the highest modulus of elasticity and is the most rigid foam at room temperature. However, while the modulus of elasticity of urethane is lower, it maintains its modulus of elasticity better at elevated temperatures.

From a paper entitled "The Properties of Cellular Plastic Material," presented before the Cellular Plastics Division Conference of The Society of the Plastics Industry Inc., in New York, October 1957.

Types and applications of

Thermistors

Thermistors are used in applications where it is desirable to change or adjust resistance of an electrical circuit without any moving parts, or where it is necessary to control or measure temperature, or counteract effects of temperature variations in electrical circuit components.

A THERMISTOR is a resistor whose value varies with temperature in a predetermined manner. The word "thermistor" is a contraction of thermal resistor, a term descriptive of thermistor characteristics.

Principal uses and applications of thermistors come from their large change in resistance with very small changes in temperature. Resistance of thermistors decreases as their temperature rises and increases as it falls. This characteristic is directly opposite to that of ordinary resistors that normally have small positive temperature coefficients.

Construction: Thermistors are made of various mixtures of the oxides of manganese, nickel, cobalt, copper, uranium, iron, zinc, titanium, and magnesium. These semiconducting materials are mixed in proper proportion to get required resistance and temperature coefficient of resistance for particular applications.

Mixtures are formed into various shapes and sintered under accurately controlled atmospheric and temperature conditions. The finished product is a hard ceramic material that may be mounted in many ways depending on mechanical, electrical, and thermal requirements.

Thermistors have good stability, are mechanically rugged and shock resistant, make permanent electrical contacts, have a wide range of resistance, temperature coefficient, and power dissipation. They are small, compact in size, and have unlimited life when operated within maximum temperature ratings. Thermistors have three forms: Beads, disks or washers, and rods.

Bead-Type Thermistors: Bead thermistors are small spheres of thermistor material that can be formed on two parallel platinum wires. Spacing of the wires, chemical composition of the bead material, and heat treatment of the bead element are the principal factors which determine electrical characteristics of the bead.

The beads are mounted in various ways for many different applications. They may be enclosed in very thin glass or mounted in gas-filled or vacuum bulbs. Bead-type thermistors are used for high-frequency power measurement, oscillator amplitude control, and flow-rate detection. They are also used as the sensing device in measurement of extremely small differential temperatures.

Some bead thermistors are indirectly heated. These types have a more complicated construction. The bead is surrounded by, but electrically insulated from, a separate heater to which power is applied to heat the thermistor. In this manner, the temperature of the thermistor and, consequently, its resistance, can be changed or controlled.

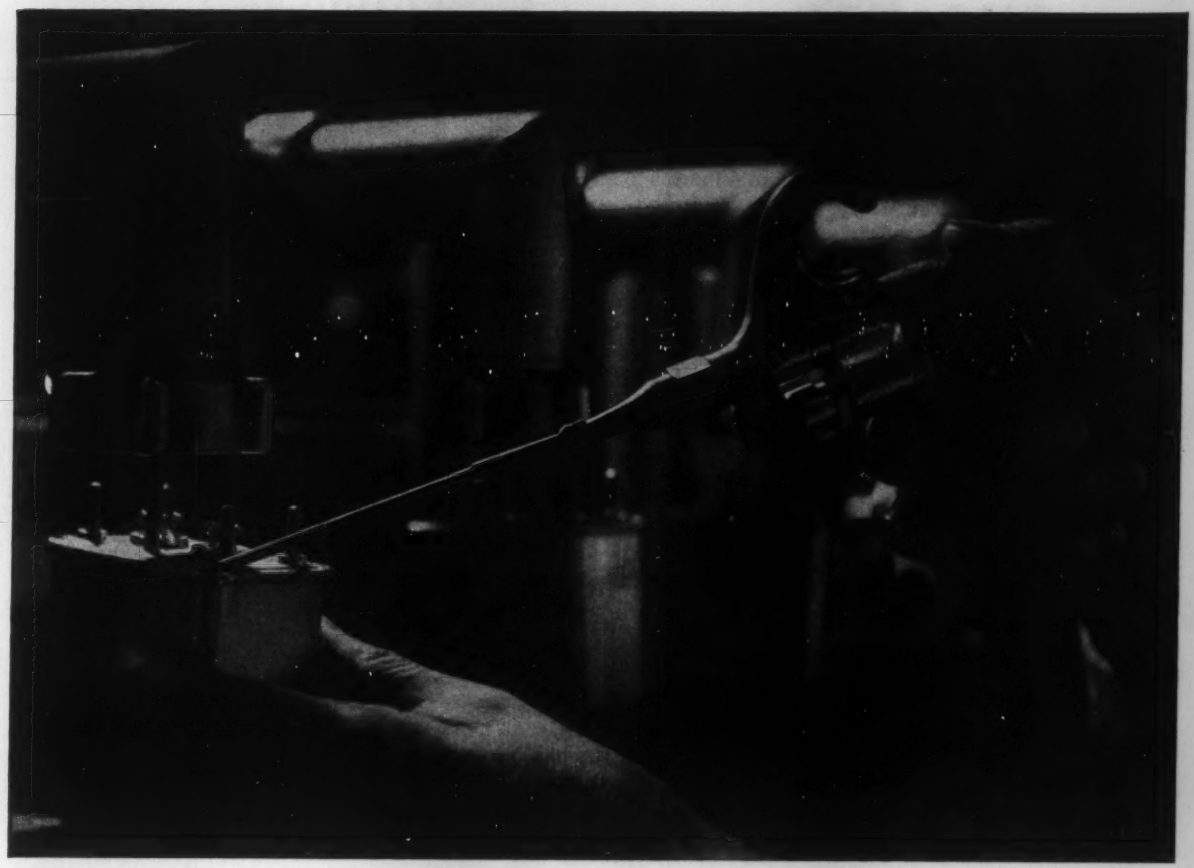
Bead thermistors can be modified to adapt them to widespread uses. Because of their small size, they are ideal for devices with extreme space limitations and for the same reason, they respond rapidly to very small amounts of power. The smallest units have time constants in the neighborhood of ½ sec.

Disk-Type Thermistors: Thin, large diameter units have a low resistance, short time constant, and high power dissipation. Thick, small diameter units have high resistance, long time constant, and low power dissipation. The disk shape is convenient for units placed in close thermal contact with flat metal surfaces.

Rod-Type Thermistors: Rod thermistors are made as long narrow rods of circular cross-section with contacts connected to the ends of the rods. These units have moderate power dissipation, long time-constants, and high resistance values.

Besides being used in most of the same ways as disks and washers, rods are used where high resistance is a consideration. Thermistor rods are useful as sensing elements, in electronic thermometers, temperature actuated controls, and compensators for temperature effects in electronic circuits, and for time delay.

Electrical resistance of the thermistor is a function of its absolute temperature and, consequently, all of its useful characteristics are based on the fact that its resistance will change as its temperature changes. Methods of producing temperature changes with consequent resistance changes in ther-



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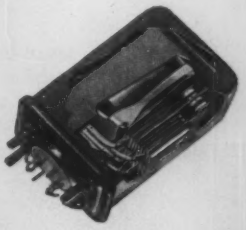

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mistors may be divided into three major groups: Thermal, electrical, and physical.

Thermal Control: When a thermistor is used in an electrical circuit in such a way that power dissipated in the thermistor is insufficient to heat the thermistor above its surrounding temperature, the temperature of the thermistor will be the same as ambient temperature.

Under these circumstances, resistance of the thermistor becomes a function of ambient temperature and, therefore, can be used to measure variations in ambient temperature. This characteristic makes the thermistor useful for temperature measurement, temperature control, and temperature compensation.

By connecting a thermistor to a fairly simple resistance measuring device, temperatures may be measured easily to a precision of a thousandth of a degree. By using thermistors with suitable electronic equipment, temperatures may be controlled with even greater precision.

Thermistors may also be used to counteract effects of temperature variations in other electrical circuit components such as meters of conductors with positive temperature coefficients of resistance.

Electrical Control: Thermistors may be connected into electric circuits in such a way that power dissipated in the thermistor heats the thermistor appreciably above ambient temperature. To get this dissipation of power, heat produced in the thermistor itself may be used, or heat may be produced by a small heater coil very closely associated with the thermistor.

Under these circumstances, resistance of the thermistor is a function of power dissipated in the thermistor or in its electrical heater.

When power is applied to a thermistor, there is some lag between application of power and heating of the thermistor to its final temperature. Length of the time lag is a function of the thermal mass of the thermistor and its associated heater.

A bead thermistor that has extremely small thermal mass will react very rapidly and may give time delays of a small fraction of a second. With larger thermistors, time delays of the order of minutes are also feasible.

There are many applications for thermistors that put these resistance-temperature characteristics to use, such as constant voltage controls, constant current controls, power level and gain controls in amplifiers, surge suppression, overload protection, and time delay.

Control of Physical Conditions: When a thermistor is used in a circuit in which the thermistor is heated above its ambient temperature, the temperature to which the thermistor is raised is a function of a construction of the thermistor and its surroundings.

Changes in environment produce changes in the temperature and consequently in the resistance of the thermistor. This characteristic makes it possible to measure changes in environment by means of the resistance of the thermistor.

For example, a thermistor electrically heated in still air will reach a much higher temperature than when it is similarly heated in moving air. Useful applications for thermistors that make use of this characteristic include measurement of gas composition by thermal conductivity, measurement and control of flow rate of liquids or gases, and measurement and control of pressure and liquid level.

From "Types and Uses of Thermistors," in Bureau of Ships Journal, *Vol.* 6, *No.* 6, *October,* 1957.

Welding and brazing of

Precipitation-Hardening Steels

By F. K. LAMPSON
Marquardt Aircraft Co.
Van Nuys, Calif.

WELDING and brazing of PH steels differ from the ordinary 400 series stainless steels in that they can be joined in the austenitic condition where susceptibility to cracking is decreased. Categorically, it appears that AM 350, AM 355, and Armco 17-7 PH stainless steels should be fusion welded in the annealed condition, followed by heat treating operations in order to achieve maximum weld efficiency. For tungsten inert gas arc processes, which are ideally suited for these materials, filler metal should be of the same nominal composition as the base metal. In cases where the material may be required to be welded in the hardened condition, or where the strength of the weldment is secondary, it is permissible to fusion weld these materials using filler metal of the same type used for welding austenitic stainless steels.

Aluminum Oxidation: One problem which is inherent with the 17-7 PH grade is that of the danger of loss of aluminum by oxidation during the welding process. The problem of aluminum oxidation is decreased in the tungsten inert gas welding process by using slightly higher argon gas coverage than

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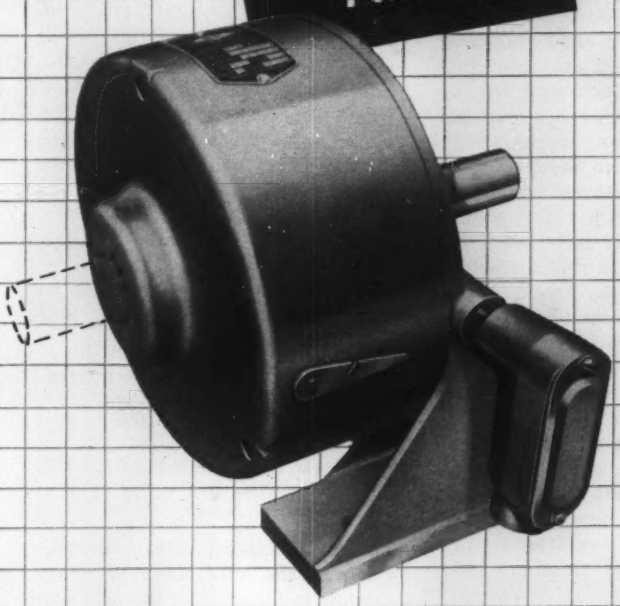

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Also available without shaft Reuland disc type magnetic brakes are also supplied for applications where the motor or equipment shaft can be extended directly into the brake. These units are available in both foot-mounted and endbell mounting types. Together with the completely self-contained unit described above, these brakes provide low cost, compact size and efficient operating features that are unequaled.

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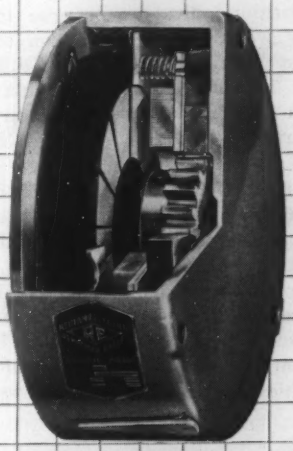

Cutaway view of endbell mounting type

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normally used for austenitic stainless steels. Argon gas provides a protective gas coverage which prevents oxygen in the air from coming in contact with the aluminum of the steel. Metallic arc welding of 17-7 PH is normally accomplished using flux-covered electrodes of 17-4 PH composition. Metallic arc electrodes to 17-7 PH composition are not normally manufactured because the flux coating does not provide sufficient protection to prevent oxidation of the aluminum content.

Welding A-286 Alloy: Fusion welding of A-286 alloy should be performed upon material in the annealed, or solution treated, condition, since this alloy is very susceptible to cracking during welding in the fully aged condition. Considerable success has been achieved using filler metal with Hastelloy W (Ni-base Cr-Mo) composition where the technique is adjusted to require favored dilution of the base metal. Several large consumers of this material have reported considerable success using filler metal to the base metal composition, a situation which is to be preferred where the part is to be heat treated after welding.

Brazing: Brazing of 17-7 PH steels with brazing materials of the silver-manganese type has been widely accepted, primarily in the fabrication of honeycomb panels and structures. It has been reported, however, that silver-manganese brazed joints are subject to crevice-corrosion. Additions to the composition of such elements as lithium and/or nickel have been attempted with varying degrees of success. Brazing cycles are normally coordinated with the "double aging" type of heat treatment, with the result that this material provides the ultimate in high strength, low density structures for use up to 800 to 1000 F, depending upon time of exposure. Here again, however, aluminum presents problems with regard to oxidation, with the result that brazing operations are carried out in dry hydrogen atmospheres. There have been cases reported where the brazed assembly was covered with a white powder after the brazing cycle, with the white residue being identified as aluminum oxide. This condition indicated that the aluminum content of the base metal has been depleted, a condition which is dangerous because the austenite becomes stable and full response to heat treatment is not realized and results in a weakened structure. It is believed that dry hydrogen atmosphere with dew points lower than −50 F are required to prevent oxidation of aluminum during brazing.

There has been very little production brazing of AM 350 and 355 steels, but the composition indicates that little difficulty would be encountered using conventional brazing filler materials. This has been verified by several of the large airframe manufacturers.

Brazing A-286 Alloy: Nickel alloy brazing of A-286 alloy presents many problems due to the presence of aluminum and titanium. These elements are not reduced by hydrogen, with the result that normal brazing techniques performed in a dry hydrogen atmosphere are not sufficient to achieve reproducibly satisfactory bonds. To support the theory that it is the presence of titanium and aluminum that creates the difficulty when brazing A-286 material, it has been shown that as-forged parts, with one surface finish machined, have been found to bond perfectly along the as-forged surfaces but not along the machined surfaces. It is believed that aluminum and titanium, which are easily oxidized, are depleted from the as-forged surface, a condition which results in satisfactory bonding due to the increased wettability of the nickel alloy brazing alloy and the base metal.

The following procedure for nickel alloy brazing has been found to work very well:

1. Subject the part to brazing temperature and atmosphere in the absence of braze filler metal.
2. Vapor blast the parts.
3. Braze at 1950 F using AMS 4778 filler metal with a dew point of −60 F or better.

The vapor blasting operation, which removes the surface layer of titanium and aluminum leaves a surface which is metallurgically clean to the brazing filler metal. Recourse to AMS 4778 filler metal in lieu of the more familiar AMS 4775 filler metal is required for particular operations but AMS 4777 has been found to work very well. Both AMS 4777 and 4778 appear to have greater wettability than AMS 4775 material, and are considered better for the brazing of A-286 alloy material.

From a paper entitled "Metallurgical Design Considerations for Precipitation Hardening Steels up to 1200 F," presented at the SAE National Aeronautic Meeting in Los Angeles, Calif., October 1957.

How to develop Maximum Reliability of a Design

By G. S. SCHAIRER and H. S. CLAYMAN
Boeing Airplane Co.
Seattle, Wash.

A DESIGN, as initially conceived and released from the drawing board, has the capability of eventually reaching some maximum value of reliability that might be described as its potential reliability. It is the reliability that is expected from this design after components and systems have become fully developed. Despite the best efforts, initial reliability will normally be subject to im-

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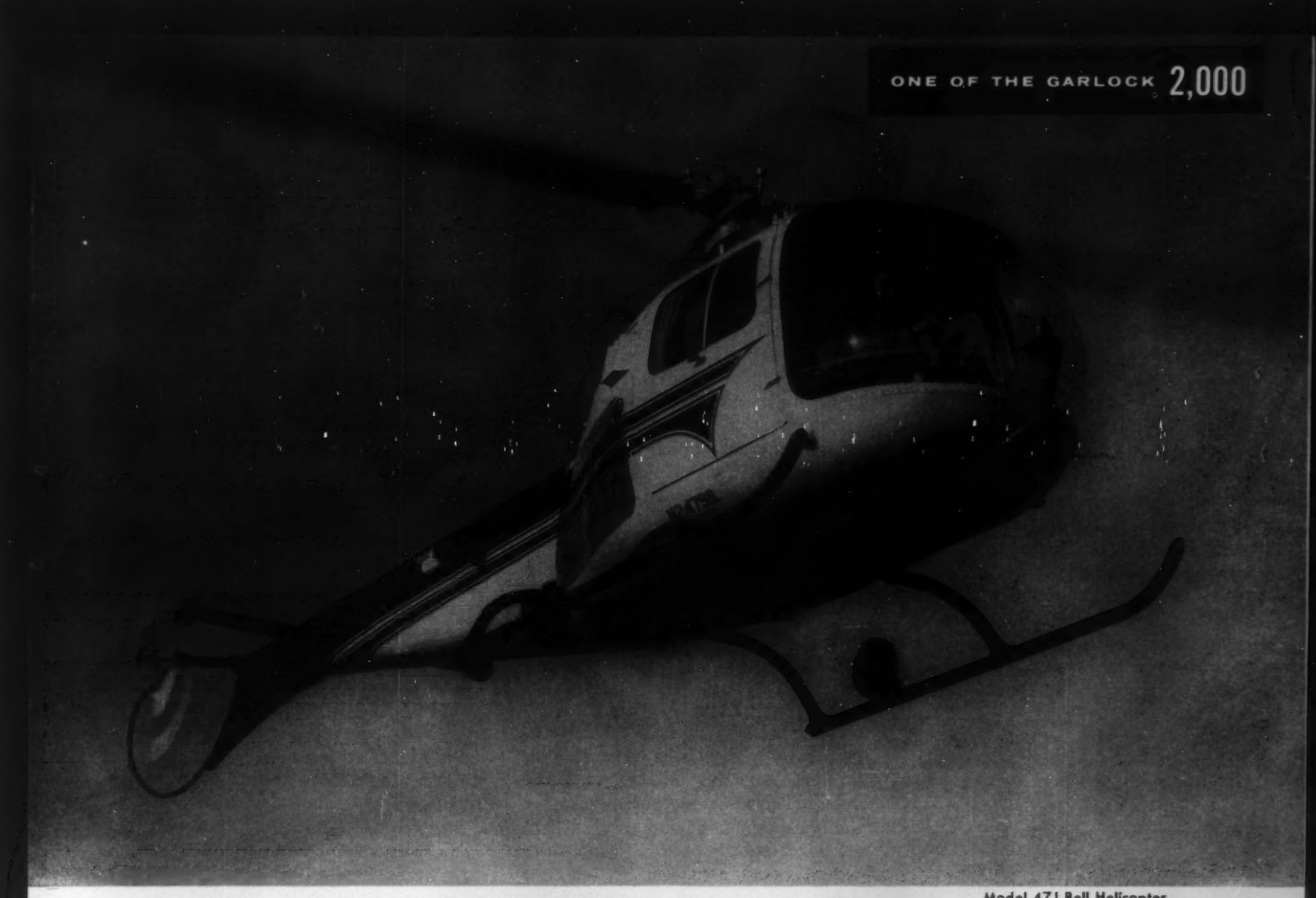

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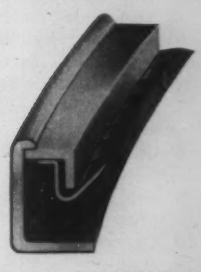

Cross-section of Model 51 Garlock KLOZURE Oil Seal designed for medium-speed rotary service and low pressure reciprocating service. This seal is used in the Transmission Assembly and in the Tail Rotor Gear Box of the 47J Bell Helicopter.

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provement. With test and operational experience, changes can be introduced that allow the reliability potential of the design to be reached. The important point is that the potential reliability depends principally upon decisions made during initial design.

The designer faces the combined problem of making a design with high potential reliability and then conducting the subsequent design refinement program so that the reliability potential is realized as soon as possible, preferably before the customer becomes too deeply involved. This process of improvement from initial reliability to potential reliability is primarily accomplished by a feedback of operating experience and a follow-up with corrective actions. Corrective actions will result in design changes, retrofit modifications, and in modified operation and maintenance practices.

Design steps necessary to achieve a reliable product are:

1. Define reliability problem.
2. Define reliability terminology.
3. Establish reliability goals.
4. Assign responsibility.
5. Analyze reliability problems.
6. Accomplish laboratory tests to obtain design data.
7. Accomplish design and reliability analysis.
8. Carry out laboratory qualification tests.
9. Set up failure-data feedback programs.
10. Carry out follow-up actions.
11. Measure and evaluate overall product reliability.

Defining Reliability: Design actions must be implemented to establish reliability requirements of both the initial design and subsequent follow-up. Although it will be extremely difficult to tie the problem down, it is most important that this be done by establishing working definitions of what is meant by reliability, by evolving a standard terminology and by the establishment of reliability goals. It is necessary that this be accomplished in terms suitable for the design objectives and subsequent quantitative and qualitative performance evaluation. To the maximum extent possible, the problem must be defined and measured.

Establishing Responsibility: To obtain better reliability, not only must the reliability goals be established, but responsibility and authority for reaching these goals must be clearly assigned. This must include responsibility for an analysis to indicate that the design meets the intended goals to the best extent that it can be predicted. Analysis and design will frequently be the responsibility of two different groups as is the case in stress analysis which is normally not accomplished by design groups. A stress analysis usually concentrates on safety aspects but can be expanded rather readily in many areas to encompass other reliability considerations. Similar analysis reports should be prepared for all important elements affecting reliability.

Analyzing Reliability: An analysis on each subsystem of the design might contain a performance analysis detailing exactly what the system is expected to do, a failure analysis which considers ramifications of the failure of each individual component and categorizes each failure, and a probability analysis detailing probability of failure of each component utilizing the best available substantiating data. The report should give special consideration to multiple failures and any single failures which will result in a safety problem.

Qualification Tests: Formal qualification testing, distinct from the experimental nature of laboratory testing, is very important to the overall reliability program. The tests must be realistic and severe enough to simulate the range of expected practical operation. The testing must be accompanied by a complete recording of all difficulties. There must be a mandatory requirement for design correction of each new difficulty when it shows up for the first time.

Although qualification testing is important, it must be remembered that having one piece of equipment pass a test does not necessarily mean that the performance of large numbers of these items in the field will be equally satisfactory for either short or long periods of time. Testing should simulate the customer's operation as closely as possible and equipment should not be protected unduly from hazards of normal operation. Steps must be taken to insure that workable operation and maintenance procedures are established during the program. Accelerated testing should be conducted by the manufacturer and customer at the earliest possible time.

Failure-Data Feedback: Malfunction reporting generally provides a statistical summary and a basis for corrective action. A statistical summary of all failures is necessary for a perspective as to which failures are more frequent, which failures are increasing in frequency, and also to correlate contributing factors. Not all corrective actions can be given equal priority. High risk and high-cost items must receive first attention. Statistical data are necessary from the beginning and will materially assist in determining where emphasis must be placed.

Statistical data alone, however, accomplishes nothing with respect to eliminating failure causes. Data must be sufficiently detailed and descriptive to permit the designer to ascertain the nature of the failure and to enable him to initiate corrective action. The man in the field should assume that each new difficulty, regardless of how small, is the first encounter of a problem which he will see many times.

Follow-up Action: These actions will be of many types ranging from design changes through inspection procedures to operating and maintenance actions. An improvement in the next component to come off the production line is not the complete solution to the follow-up problem. Parts already in the field must be given equal consideration. Often the designer is so isolated from the operator that he feels the problem is solved with a change of parts being built. The designer must assume the responsibility for planning the reliability improvement program and must include in his planning consideration of parts long since delivered.

From a paper entitled "Design for Reliability," presented at the SAE National Aeronautic Meeting in Los Angeles, October, 1957.

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Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Coordinate Cathetometer

Details of the new coordinate cathetometer are presented in Bulletin 194-57. This optical measuring instrument makes vertical and horizontal measurements and is suited for layout, inspection, research, and quality control operations. 2 pages. Gaertner Scientific Corp.

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Tube & Bar Stock

Detailed information on standard bar and tube stock offered in GC Meehanite Metal, GA Meehanite Metal, and Type No. 1 Ni-Resist is presented in Bulletin 156. These centrifugally cast bars and tubes are suited for making bearings, bushings, gears, liners, pump and valve parts, pistons, sleeves, sprockets, and other items. 6 pages. Shenango Furnace Co., Centrifugally Cast Products Div.

Circle 652 on Page 19

Nonferrous Castings

Physical properties and conforming specifications for magnesium and aluminum alloys are tabulated in Catalog 57. Listings include alloys for sand castings, permanent mold castings, and rare earth alloys. 24 pages. Wellman Bronze & Aluminum Co.

Circle 653 on Page 19

Sprocket Chain

Usable for low-torque drives, manual controls, timing elements, and other applications, precision sprocket chain described in illustrated bulletin is of controlled-pitch, miniature type. Sizes range from 78½ to 34 links to the foot in 21 to 14-gage wire, respectively. 4 pages. Hodell Chain Co.

Circle 654 on Page 19

Regulator Valves

How to size OPW-Jordan sliding-gate regulator valves and how to adjust sizing for variations in pressure, temperature, viscosity, specific gravity, and other variables is explained in Bulletin J-SC. Charts cover steam, liquid, and gas services. 4 pages. Jordan Corp.

Circle 655 on Page 19

Stainless Steels

Strength factors, physical properties, chemical composition, typical applications, and thermal treatment for a series of stainless steels are given in illustrated brochure. Thirteen steels for diversified uses are covered. 32 pages. Sharon Steel Corp.

Circle 656 on Page 19

Relay

Features of Class E miniaturized telephone style relay are outlined and its specifications are given in "Relay Highlights No. 14." Forms of standard contact springs are shown. Operation is on up to 150-v dc or 220-v ac. 2 pages. Automatic Electric Sales Corp.

Circle 657 on Page 19

Lubricator

Description and details of operating mechanism of a lubricator actuated by a machine's hydraulic cycle is found in illustrated Bulletin TR-57C. The Cyclic Y unit operates on line pressures from 500 to 3000 psi. 2 pages. Bijur Lubricating Corp.

Circle 658 on Page 19

Heat Treating Steels

Data on heat treatment of Croloy 2¼ alloy steels, Grades T22 and P22, are content of Alloy Sales Letter 289M. Covered are mechanical properties, isothermal transformation characteristics, and TTT diagram. 4 pages. Babcock & Wilcox Co.

Circle 659 on Page 19

Ceramic Seal Material

Ceramicite C-100, a high temperature ceramic material for hermetic seal applications is subject of data sheets. It bonds physically with stainless steel and is available in preforms and completed seals. Technical details are given. 4 pages. Consolidated Electrodynamics Corp.

Circle 660 on Page 19

Hard-Facing Alloys

Chemical composition, properties, typical applications, and application procedures for 11 Haynes hard-facing alloys are covered in booklet "Haynes Hard-facing Alloys—Bare Rods, Powder, Crushed Particles." Iron, cobalt, and nickel base alloys and cast tungsten carbide are included. 8 pages. Haynes Stellite Co.

Circle 661 on Page 19

Engines & Power Units

Horsepower and speed ratings of Golden Power line of engines and power units are content of Bulletin 1034C. Included are LP gas, natural gas, gasoline, and diesel units. Maximum brake horsepower at certain indicated speeds is given. 4 pages. Minneapolis-Moline Co.

Circle 662 on Page 19

Arbors & Chucks

Data for selection of interchangeable extension arbors and tapered shank collet chucks for internal grinding and milling spindles are found in illustrated Bulletin WA-10. Covered are 250 styles and sizes of arbors. Also described are self-removing wheel holders for various types of grinders. 30 pages. Pope Machinery Corp.

Circle 663 on Page 19

Resolver

Tuned impedance of 10,000 ohms which permits operation over a wide voltage range is feature of Size 15 resolver. Described in illustrated Bulletin 438, it has an accuracy within ±0.1 per cent from −55° to 85° C. Characteristics are given. 2 pages. Norden-Ketay Corp.

Circle 664 on Page 19

High Pressure Valve

Engineering drawings and engineering information on the Cash Standard Type 505 high pressure control valve are included in bulletin. Designed for 10,000-psi service, it provides close control of gases and liquids. Specifications of available types are given. A. W. Cash Co.

Circle 665 on Page 19

Centrifugal Fans

Engineering data on BC airfoil centrifugal fans are available in illustrated Bulletin 257. Construction details, capacity tables, dimensional drawings, and suggested application arrangements are among contents. 32 pages. Ilg Electric Ventilating Co.

Circle 666 on Page 19

Silicone Rubber Sheets

Properties of 50, 60, and 70 durometer hardness silicone rubber sheets and fabric-reinforced silicone rubber sheets are detailed on Bulletin SR-57. They are suited for applications from −85 to 500° F. 2 pages. Connecticut Hard Rubber Co.

Circle 667 on Page 19

Fasteners & Small Parts

Illustrated Catalog 106 covers design and use of such cold heated specialties as rivets, nails, screws, and other fasteners and small parts. Data includes cost and design advantages and manufacturing possibilities, plus information on metals and finishes. 16 pages. John Hassall, Inc.

Circle 668 on Page 19

Aircraft Hose Assembly

Springfield 120 Teflon aircraft hose assembly with Titeflex reusable fittings is described in illustrated aviation catalog supplement. Aircraft hose offers chemical resistance, inertness, and thermal stability. Specifications are given. 4 pages. Titeflex, Inc.

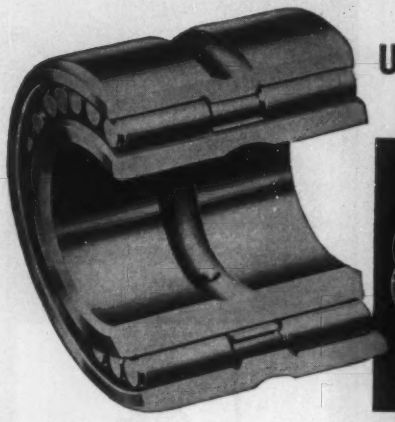
Circle 669 on Page 19

O-Rings

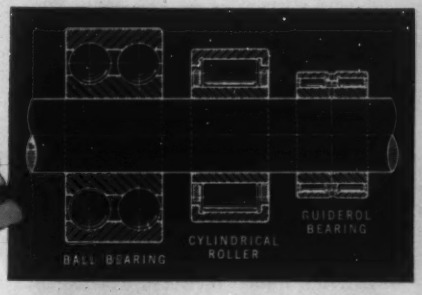
Range of industrial O-rings in standard sizes and compounds is described in illustrated Bulletin OR-57. It lists standard O-rings keyed to an SAE uniform numbering system. Compounds formulated for a broad range of uses, hardness ratings, and

BEARING TIPS by McGill

To pack more performance in smaller space



Use space-saving McGILL GUIDEROL® needle bearings

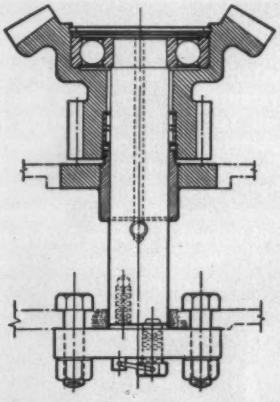


Showing graphically how a McGill GUIDEROL precision needle bearing permits more streamlined designing by supporting comparative loads in significantly smaller radial space than other types of bearings. Bulky and more costly housing space is easily avoided.

The McGill GUIDEROL Bearing combines the inherent high-load capacity of a full complement of full race width rollers with a center roller guiding principle that limits skewing and binding under misalignment. This qualifies the bearing for a whole range of applications that are too heavily loaded for a retainer-type bearing and are subject to the misalignment that precludes use of an ordinary needle bearing. For outstanding performance in small radial space, use GUIDEROL precision needle bearings. Specify the interchangeable sealed SGR series for added protection against contamination.

GUIDEROL® bearing capacity, space economy proved in power shovel vertical reversing shaft assembly

Baldwin - Lima - Hamilton Corp. uses a McGill GUIDEROL bearing, on ½ cubic yard power



shovels, to carry spur pinion loads in the vertical reversing shaft. The high capacity of the bearing in small radial space is an important factor in selection of this bearing. Only 3.75" in diameter, it has a load capacity of 28,560 lbs. at 100 rpm. In the power shovel application, it supports 14,150 lbs. at 76.3 rpm, which gives a high margin of safety. The center guided rollers also are especially adaptable to a vertical application such as this.

Fact-packed Bearing Catalog

Write for your copy of Catalog #52-A, a 128 page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.

Multiple spindle drill heads require support of spindles on very close centers

Crowding a great number of drill spindles into a small area, Zagar, Inc., of Cleveland has found the McGill GUIDEROL bearing construction especially suited to the needs of multiple drill head units. The full bearing width rollers provide rigidity and more than adequate load capacity and in a bearing only 1.25" in bore diameter.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

BEAVER BALL SCREWS

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficient in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments, aircraft, machine tools, massive wind tunnel jacks, etc. For horizontal and vertical actions, indexing, inching and traversing. Consultation and engineering service available. Write for literature.

• EXTREME ACCURATE POSITIONING • NO BACKLASH • RAPID START • ANY DIAMETER OR TRAVEL •

Beaver Precision Products INC.
CLAWSON, MICH.

Circle 492 on Page 19

Helpful Literature

other data are covered. 8 pages. Chicago Rawhide Mfg. Co.

Circle 670 on Page 19

Interval Timers

Hermetically sealed series of precision interval timers described and illustrated in Bulletin AWH RC-300 are available with either chronometrically governed dc motors or synchronous ac motors. Overall ranges in excess of 30 to 1 can be supplied. 2 pages. A. W. Haydon Co.

Circle 671 on Page 19

Electronics Facilities

Detailed facts and figures on company's electronics "Engineering and Production Capabilities" are published in this illustrated brochure. Wide variety of equipment and facilities is listed, and special abilities are covered. 12 pages. Lear, Inc., Learcal Div.

Circle 672 on Page 19

Beryllium Oxide

High thermal conductivity, electric resistivity, and dielectric strength are combined in beryllium oxide, subject of descriptive technical bulletin. Properties of the refractory oxide are discussed, as are beryllium oxide powder, crucibles, crucible wash, and shapes. 8 pages. Beryllium Corp.

Circle 673 on Page 19

Electronic Connectors

First issue of "Electronic Connector" presents recent developments and designs in electronic connectors and components. Covered are high voltage-high corona level, high temperature-high altitude, triaxial cable, and other types of connectors. Those interested will be added to the mailing list. 4 pages. H. H. Buggie, Inc.

Circle 674 on Page 19

Solenoid Valves

Condensed data on two, three and four-way; corrosion resistant; manual reset; and special purpose solenoid valves, as well as on such electromagnetic controls as automatic transfer switches, remote control switches, contactors, solenoids, and electric plant controls are contained in Form VS-51. 4 pages. Automatic Switch Co.

Circle 675 on Page 19

Silicone Molding Compounds

Discussed in Bulletin 7-603 are the low thermal conductivity, superior electrical properties, and high temperature strength-to-weight ratio of silicone molding compounds. Charts, graphs, and field examples amplify the text. 4 pages. Dow Corning Corp.

Circle 676 on Page 19

Differential Analyzer

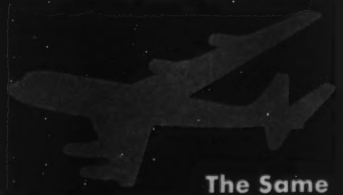
Described in Form 3005-7 is the model 695 single-channel differential analyzer for separating groups of pulses of varying amplitudes. 2 pages. Victoreen Instrument Co.

Circle 677 on Page 19

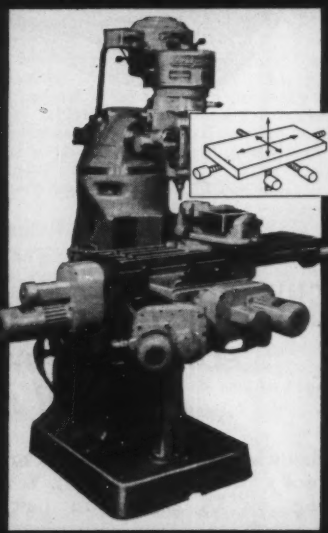
Hose Assemblies

Engineering and design information on fluorocarbon flexible hose and hose assemblies for use in missiles

BROAD APPLICATION!



The Same Beaver Ball Screws Used Extensively in the Ships You Ride Offer Better Control in Machine Tools Too!

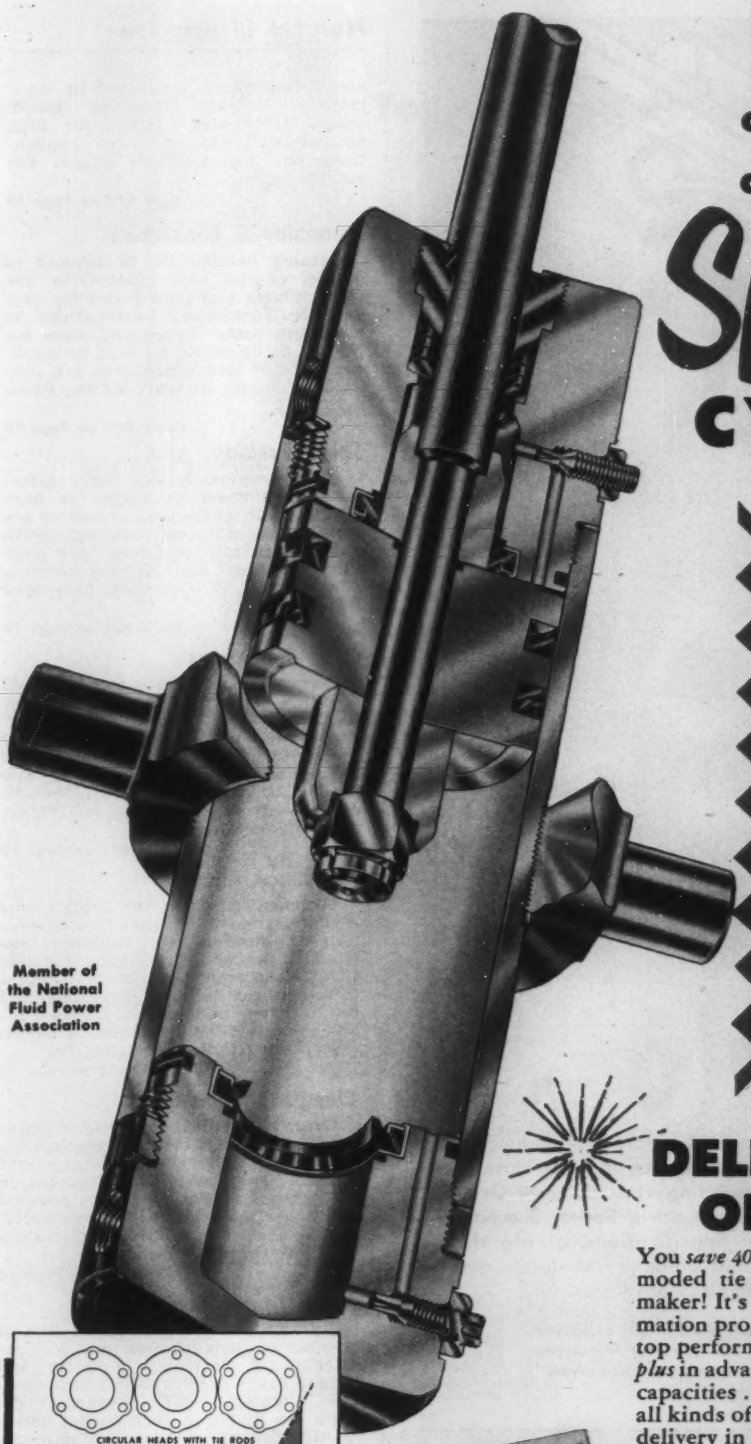


This Bridgeport milling machine with DIGIMATIC tape control system by Electronic Control Systems, Inc., employs Beaver Ball Screws for activating the table in 3 dimensions. Beavers were selected for this job for their accurate positioning, speed, control, high efficiency and virtual freedom from backlash. We have worked with many machine tool builders in automating their equipment. May we help you, too?

Beaver Precision Products INC.
CLAWSON, MICH.

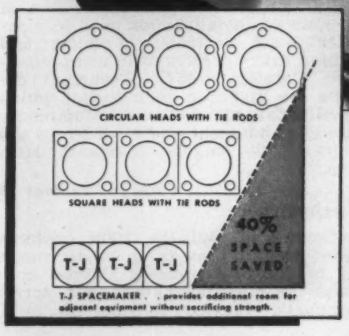
Circle 492 on Page 19

all the EXTRAS are standard with T-J Spacemaker CYLINDERS



Member of the National Fluid Power Association

- **NEW** *exclusive* ingenious cushion designs . . . Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Cushion for Oil.
- **STRONGER** than outmoded tie rod design, proven through actual tests. No tie rods to stretch.
- **SOLID STEEL HEADS** throughout the full line.
- **COMPACT DESIGN** eliminates tie rods, increasing the strength and reducing mounting space required, providing extra room for adjacent equipment.
- **HARD CHROME PLATED** body bores and piston rods . . . assure you of long trouble-free service. (Standard at no extra cost.)
- **METALLIC ROD SCRAPER,** not just a wiper, actually removes foreign matter from the rod.
- **PILOTED PACKING GLAND** with extra long bearing. Additional strength and support to the piston rod.
- **OIL** pressure to 750 p.s.i. AIR to 200 p.s.i.

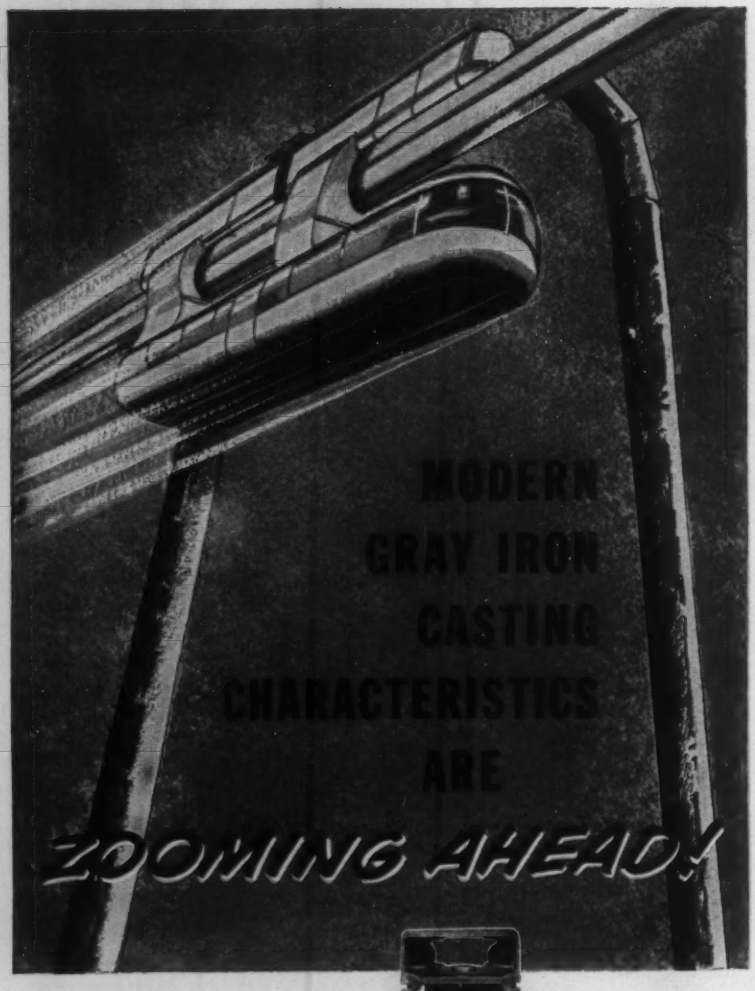


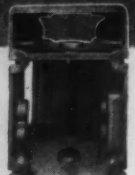
DELIVERY OFF THE SHELF!

You *save 40% space* when you switch from outmoded tie rod cylinders to the T-J Spacemaker! It's stronger, too! Fits right into automation programs in countless plants. Delivers top performance and dependability with a big *plus* in advanced features. Wide range of styles, capacities . . . reduces man-hours and costs in all kinds of push-pull-lift operations. Off-shelf delivery in 64,000 combinations!

NEW LITERATURE—Send today for new Catalog SM56 with complete engineering details on Spacemaker line. Write The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
RIVITORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHORS





This Gray Iron machine base saved 50% over fabricated steel design. It also improved the appearance and added desired performance factors.

With today's new ductile irons, users are buying iron castings under standard specifications with strengths more than 100,000 p.s.i.! Gray iron parts are also being used in structural applications under loads at temperatures up to 800°F. Learn how to make lower-cost products by utilizing the improved mechanical and physical properties of gray iron castings . . . *the most economical of all component parts.* Have at your fingertips the new Gray Iron Founders' Society Summary of Specifications, giving the latest properties of ductile and standard gray irons.

Free Summary of Specifications. Be sure you are fully acquainted with the new characteristics of gray iron. Ask your foundryman or write for a copy of GIFS up-to-date "Summary of Specifications".

it's time to design with

GRAY IRON CASTINGS

GRAY IRON FOUNDERS' SOCIETY, INC.
National City-East 6th Bldg. • Cleveland 14, Ohio

Helpful Literature

and aircraft are presented in illustrated "Aircraft Plumbing Handbook." Hose and fittings for high temperature and corrosive applications are described. 64 pages. Resistoflex Corp.

Circle 678 on Page 19

Terminals & Connectors

Catalog Section PG is devoted to details of the new Plasti-Grip line of terminals and connectors for pre-insulated, solderless terminations at minimum costs. Types and sizes for No. 10 to 24 wires, as well as application tools and procedures are covered. 20 pages. Aircraft-Marine Products, Inc.

Circle 679 on Page 19

Sheet Packing

Uses, properties, and other information on sheet packings for handling liquids, gases, and abrasives are detailed in Catalog Section 5000. Sheeting is also adaptable for matting, padding, and bumper service. 4 pages. B. F. Goodrich Industrial Products Co.

Circle 680 on Page 19

Flow Regulators

Diagrams and charts in illustrated brochure "High Performance Flow Regulators for Airborne Equipment" explain the principle of operation of the devices. How they may be used in aircraft, missiles, rockets or any product is graphically shown. Specifications are given. 8 pages. Waterman Engineering Co.

Circle 681 on Page 19

Frequency Analysis

Technical notes on the applications of Panoramic techniques in the solution of measurement problems are cited in series of bulletins entitled "The Panoramic Analyzer." Actual case histories will be presented, and the function and uses of various instruments will be discussed. 4 pages. Panoramic Radio Products, Inc.

Circle 682 on Page 19

Clamps & Fasteners

Gearlock clamps, described in Catalog cf57, use a wormlock mechanism to provide air and moisture-tight seals in heavy containers with closure strengths to 2000 lb. Also covered are hook, loop, hinge, spring loaded, and special duty clamps and fasteners. 16 pages. Bassick Co.

Circle 683 on Page 19

Small Lamp Sockets

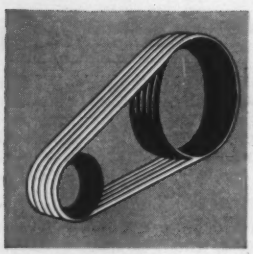
Information on a complete line of sockets for small lamps used in electrical and electronic products and equipment is presented in comprehensive Catalog S-557. Technical details are given on each socket which is illustrated full-size. Commonly used incandescent and neon lamps are shown. 28 pages. Leecraft Mfg. Co.

Circle 684 on Page 19

Fasteners

Condensed Bulletin 2008 contains brief descriptions of a broad range of industrial fasteners. Types covered include Unbrako socket screw products, Flexloc self-locking nuts,

Circle 494 on Page 19



for driving reliability . . .

No V-belt transmits power like *TEXROPE* BELTS with endless grommet construction

THICK, solid rubber cushion surrounds and protects grommets from heat, shock and other destructive factors.

Thick

Extra Strong

EXTRA STRONG, heavy twin grommets each offer more than enough tensile strength to handle any load normally encountered. They're precisely located to assure uniform load distribution.

TOUGH bias-cut, multi-fabric cover prevents penetration by heat.

Tough

Sturdy

STURDY, straight sidewalls guarantee maximum gripping power. Tendency to bulge is converted into gripping sidewall pressure because cast-iron sheave sidewalls confine the belt.

Texrope is an Allis-Chalmers trademark.

For More Information on *Texrope* belts, sheaves and other mechanical power transmission equipment, contact your nearby Allis-Chalmers distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

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MORE GRIP WITH LESS SIZE

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Automotive Spring Loaded

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Oil or Dry Multiple Disc

Heavy Duty Over Center

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Because ROCKFORD Morlife Clutches handle double the amount of torque handled by ordinary friction clutches, they enable design engineers to reduce the effect of centrifugal force developed by modern, high-speed engines. By cutting down the required diameter of the clutch, they reduce weight. By insuring better heat disposal, they multiply the clutch's work-life. While your next model is in the planning stage, it will pay you to investigate how this new type clutch will improve the operation and eliminate 90% of the clutch service requirements of *your* product.

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Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

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ENGINEERING B-W PRODUCTION

CLUTCHES

Helpful Literature

Sel-Lok spring pins, and Hallowell steel collars. Sizes, materials, and application information are included. Microsize fasteners are detailed also. 4 pages. Standard Pressed Steel Co.

Circle 685 on Page 19

Plastics

Properties of Super-Dylan, Dylan, Dylite, and Dylene polyethylene plastic materials which adapt them for wide range of uses are covered by illustrated Bulletin C-6-236. 4 pages. Koppers Co., Chemical Div.

Circle 686 on Page 19

Servomotor-Rate Generator

Engineered to meet the exacting requirements of control system engineers, Size 18 servomotor-rate generators use 115-v, 400-cycle excitation. Complete data on these precision units are given in Bulletin 869. 2 pages. Helipot Corp.

Circle 687 on Page 19

Plastic Foam & Sponge Rubber

The relative merits of sponge rubber, vinyl foam, and urethane foam, as well as their application as sealing, cushioning, and dampening components are subjects covered by illustrated booklet entitled, "To Make Your Product Better." Typical parts produced for specific applications are shown. 12 pages. Brown Rubber Co.

Circle 688 on Page 19

Hydraulic Fittings

Self-flaring, no-flare, and flare types of hydraulic tube and pipe fittings are pictured and complete dimensional and performance data are given in Catalog 556. Design data aids in engineering and application of the proper fitting for every hydraulic circuit need. 28 pages. Flodar Corp.

Circle 689 on Page 19

Switches

Heavy duty precision switches, particularly suited for uses in machine tools and industrial equipment, are depicted in illustrated Folder 84-274. Roller arm, plunger, lever, in-line, and manual actuated are but a few of the types of limit switches shown. 4 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

Circle 690 on Page 19

Dials & Nameplates

Guidance in specification of dials, panels, and nameplates is provided in "Idea File" which gives information on the various marking techniques available, including screening, photo marking, lithography, engraving, and etching. Finishes, coatings, and luminous materials are discussed, as are edge-lighted panels. 6 pages. Request on letterhead from United States Radium Co., Morristown, N. J.

Air Compressor Lubricant

Savings in air compressor maintenance costs and safety from flash fires and explosions result from use of Pydraul AC, a fire-resistant synthetic lubricant for air compressors. It is detailed in illustrated booklet. Request on company letterhead from Monsanto Chemical Co., Organic Chemicals Div., St. Louis 24, Mo.

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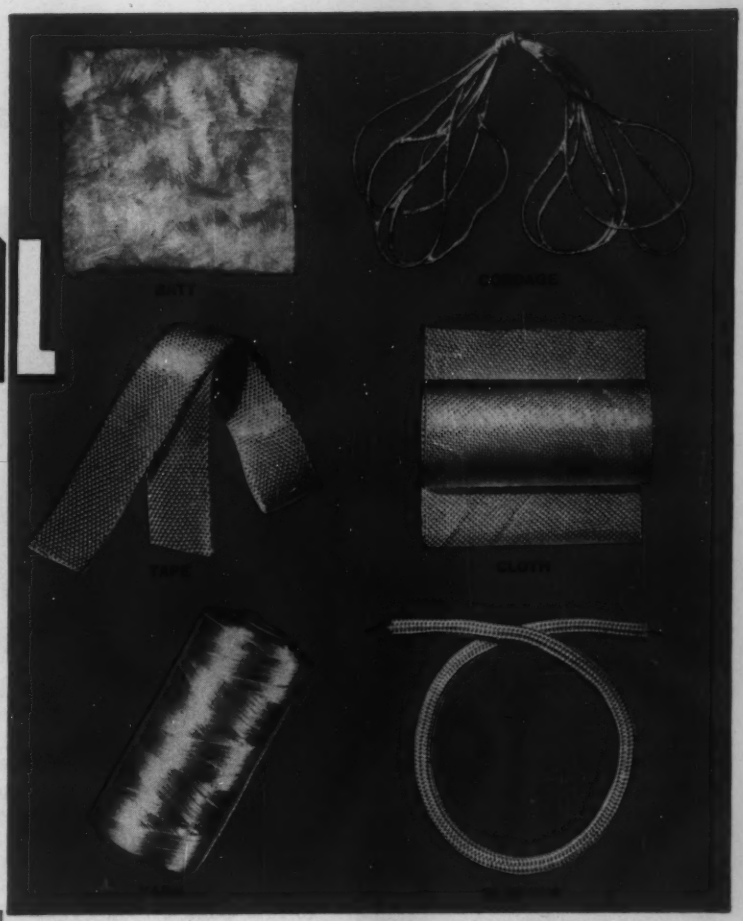
2000°-3000° F.
High Temperature Insulation

...it may be the special insulation you've been looking for!



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- Resists temperatures up to 3000°F. under certain conditions
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- Fiber diameter .00020—.00040 in.
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REFRASIL USES:

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- Thermocouple wire insulation
- Electric muffle furnaces
- Laboratory heating mantles

REFRASIL INSULATING BLANKETS:

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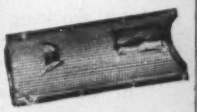

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REFRASIL has proven its high temperature insulation ability in millions of hours of jet aircraft operation. It is fast becoming an important industrial insulation for critical and extreme temperature applications from −300°F. cold to +3000°F. heat. Despite relatively high initial cost, REFRASIL is economical when restricted to special high temperature uses where ordinary insulation materials fail.

If you need an efficient, lightweight 2000°-3000° insulating material in bulk fiber or any of the physical forms shown, REFRASIL may be your best answer. For your *special* high temperature insulation problems, our research and development engineers are only a phone call away. Call or write for complete engineering information and free samples of REFRASIL, for your own testing.

• FREE NEW CHART!

First of a Series, this new High Temperature Insulation Chart contains helpful information on insulation for temperature ranges from −300° to +3000°F. Write for your free copy today!

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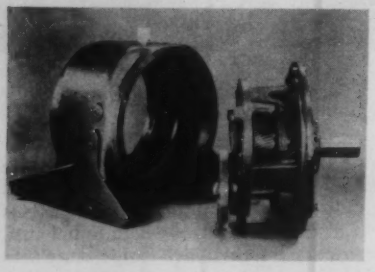
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Speed-Reducing Apparatus

makes any helical gear drive configuration

Line of helical-gear, speed-reducing units, called Moduline, provides basic subassemblies and accessories which combine to make any helical-gear drive configuration. New double-reduction cage has a fixed 5:1 set of low-speed gears. High-speed change gears are mounted on rolled spline shafts so that they can be mounted or replaced with hand tools. Gears in the triple and quadruple-reduction subassemblies are also spline mounted. Seven unit sizes to 30 hp are available with ratios of 5:1 to 625:1. Stand-



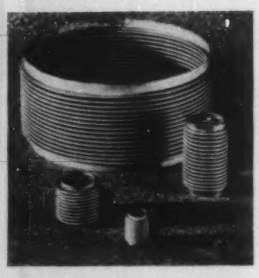
ard components can be assembled into arrangements to allow floor, ceiling, wall, or angle mounting. Addition of accessories provides for vertical flange mounting, right-angle input and output drives, gear motors, package motor reducers, and concentric-shaft speed reducers. Gear case and low-speed cage are shown. **Westinghouse Electric Corp.**, Box 2278, Pittsburgh 30, Pa.

Circle 691 on Page 19

Metal Bellows

of Inconel and Inconel-X

Metal bellows, fabricated of Inconel and Inconel-X, are available for high-pressure and high-temperature applications. The bellows



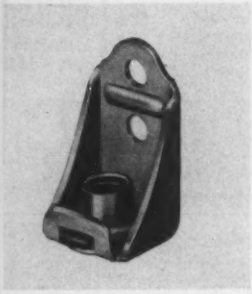
are particularly applicable in aircraft engine controls where precise response must be repeated over an extended period. A four-ply Inconel bellows of 2 in. OD withstands 1000 psi at room temperature. The materials can be used in temperatures to 1500 F. Bellows are available in sizes from 15/32 to 12 in. OD, and in single to four plies. **Fulton Sylphon Div.**, Robertshaw-Fulton Controls Co., Knoxville, Tenn.

Circle 692 on Page 19

Anchor Nut

is miniature, right-angle type

MF6000 miniature right-angle floating anchor nut has been reduced 58 per cent in weight. It is available in both cadmium-plated carbon steel, with 550-F temperature limitation, and A286 corrosion-resistant steel for higher temperature or nonmagnetic applica-

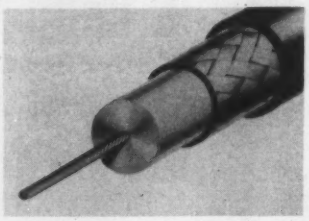


tions. Unit incorporates elliptical locking device to assure positive self-locking under severe vibration. It combines low height, high strength, and infinite reusability. Kaylock Div., **Kaynar Co.**, 820 E. 16th St., Los Angeles 21, Calif.

Circle 693 on Page 19

Miniature Coaxial Cables

are Teflon-insulated for high-temperature use



Coaxial cables are flexible units available in 50, 70, 75, 93, and 95-ohm ratings. They are insulated with Teflon for high-temperature applications, and meet the RG series of MIL-W-17B and MIL-C-8172. In addition to all-Teflon and Kel-F constructions, nylon, vinyl, Teflon and silicone-lacquered glass-braided jackets are also available. **Tensolite Insulated Wire Co. Inc.**, Box No. 66, Tarrytown, N. Y.

Circle 694 on Page 19

All-Glass Valve

2-in. unit is compact and corrosion resistant

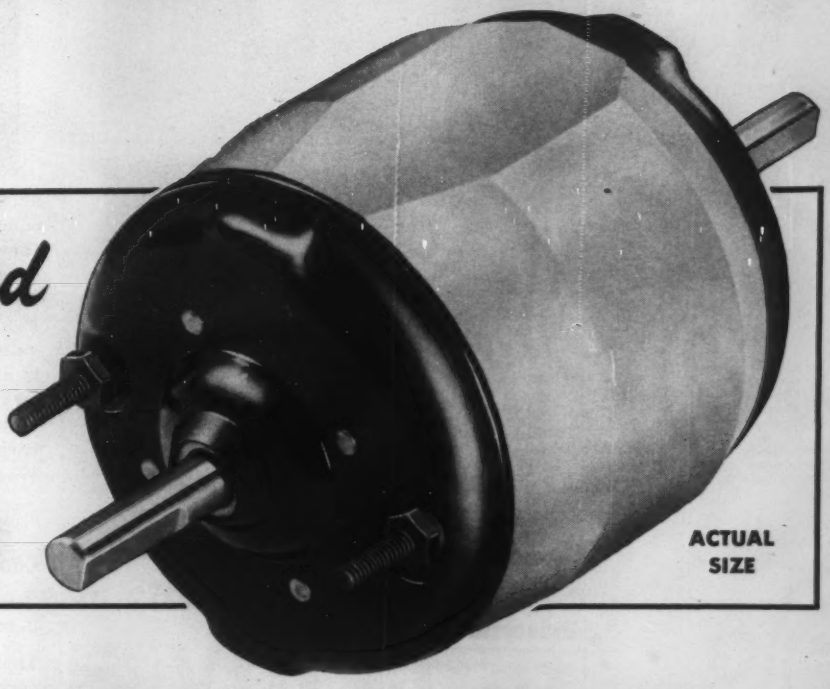
All working parts of this Y-type valve exposed to fluid are of glass or Teflon. It handles acidic fluids of all concentrations or compositions at temperatures to 250 F. The 2-in. unit is compact and corrosion resistant, and can be used to process all acidic metallic salts, various crystalline slurries, and all

MORE HORSEPOWER...

in an Economical, Compact, Quality Package

Redmond

Series
Type
MICROMOTOR



ACTUAL SIZE

Especially Designed for Actuators and All Applications Where High Starting Torque Is Needed

The Redmond type TW series MicroMotor is an especially designed actuator motor—not a modified heater motor of conventional stamped steel construction. The stator core is precision die cast to make a rigid, durable motor. The exact bearing alignment and uniformity of air gap result in a motor that will give you years of trouble-free service and quiet operation.

The TW series motor is available with 6 volt DC to 115 volt AC or DC performance winding. The horsepower range is 1/150 to ¾, depending on the speed and type of duty required.

This motor is ideal for pumps, can openers, chair vibrators and actuators, blowers, hedge trimmers, and tape dispensers. Typical automotive applications are window and seat actuators, top lifts, evaporative coolers, and air-ride compressors.

Write, wire, or telephone either the Redmond office nearest you or the home office, and our sales engineer will show you how this motor can save money on your application.

Your Nearest Redmond Engineering Field Office Has Complete Information for You

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6525 W. North Ave.
Oak Park, Illinois
Phone: Village 8-5721

Southwest Office
210 Suburban Building
5526 Dyer Street, Dallas,
Texas Phone: Emerson 8-4461

Western Office
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Redmond COMPANY, INC.
OWOSSO, MICHIGAN

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THE BIG NAME IN SMALL MOTORS

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Columbus proved the earth was round, just as Universal's 100% inspection proves the perfect roundness of its classic *precision* balls—quality controlled perfection for every possible application by designer and manufacturer. Both metallic and non-metallic materials are precision lapped to tolerances as fine as 0.000005 of an inch.

If it's round—perfectly round—it's a Universal Precision Ball.

UNIVERSAL QUALITY CONTROL—FOR ALL AROUND PERFECTION

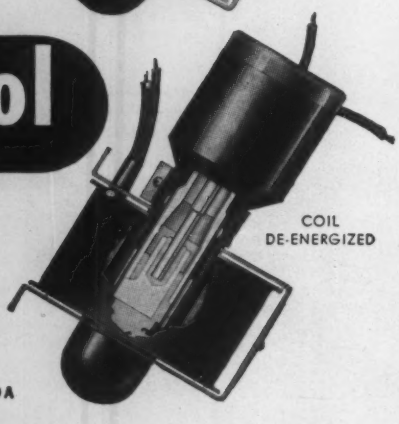
Universal Ball co.

WILLOW GROVE, MONTGOMERY CO., PA.

Circle 499 on Page 19

The **TIMER RELAY that handles all controlled timing problems . . .**

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.



Durakool

STEEL MERCURY TIMERS

★ No false contacts
★ Non sticking
★ Practically "fail safe"
★ Low cost timer

See telephone directory for local distributor, or write.

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ELKHART, INDIANA, U.S.A.
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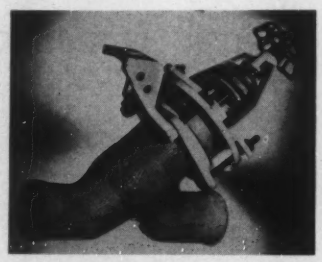
Circle 500 on Page 19

New Parts



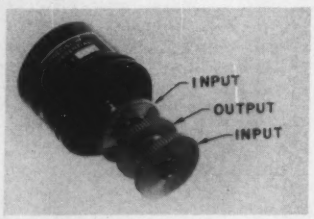
acids except hydrofluoric and hot concentrated raw phosphoric. Low thermal expansion of the glass permits a sudden temperature differential through the valve of 200 F. Maximum line pressure at the valve is 50 psi. Glass valve body is armored with a glass-fiber polyester-resin sleeve. Valve can be mounted easily in any position through 360 deg. **Corning Glass Works,** Corning, N. Y.

Circle 695 on Page 19

Concentric-Shaft Differential

for servo and computer applications

Model T-750 concentric-shaft differential is a totally enclosed, dustproof unit for servo and computer applications. Output and inputs extend concentrically from one end of a servo-mounted case. This permits mounting of the differential in alignment with stand-



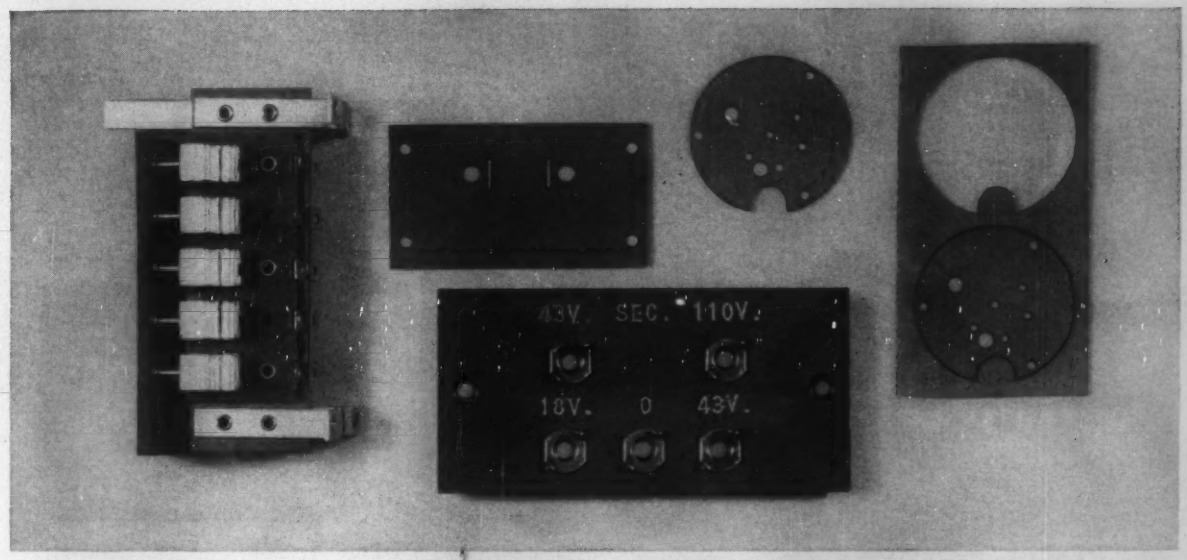
ard servo components, resulting in a single-line gear train. **Sterling Precision Corp.,** 34-17 Lawrence St., Flushing 54, N. Y.

Circle 696 on Page 19

Silicon Solar Cells

provide energy for many portable devices

Silicon solar battery cells convert light and radiant energy into electrical power of useful proportions. The p-n junction-type cells, when grouped in a series parallel configuration, become a primary pow-



LEADING MANUFACTURERS USE VULCOID. For a punched timer-switch part that operates in oil; for arc chutes in circuit breakers; for the insulation and structural part of an auto-headlight dimmer switch; for a formed electrical switch part carrying 110-volt 60-cycle current; for a mass-produced, 110-volt light-socket part—for these and many more Underwriters-approved parts, CDF Vulcoid is an effective, economical insulation material—good where neither plain fibre nor plain phenolic laminate would suffice.

Fibre gives it high arc-resistance . . .
Aniline resin gives it moisture-resistance

CDF VULCOID

resin-impregnated vulcanized fibre

Vulcoid® is *different*. To the electrical properties of vulcanized fibre we've added the low moisture-absorption of an aniline-type resin with an unusual affinity for cellulose fibers—*all at low cost*. Excellent moisture-resistance (two to four times that of plain vulcanized fibre) helps stabilize Vulcoid's excellent electrical insulating characteristics. Its low cost makes Vulcoid a fine production material for applications of moderate electrical requirements.

Underwriters' approval. Vulcoid is approved by Underwriters' Laboratories as a material for the insulation of current-carrying parts in electrical equipment. It carries the distinctive red and blue thread marking of such materials.

Easy to work. Like vulcanized fibre, Vulcoid is readily drawn or formed into permanent shapes, punched, machined (see illustration above) at low cost. CDF fabrication facilities can give you production quantities of Vulcoid parts to your specifications.

Learn all the advantages of designing around low-cost CDF Vulcoid parts such as arc-deflector spacers, transformer and motor lead bushings, circuit-breaker and transformer barriers, knife-switch guides, transformer coil separators, instrument and contact panels, baseboard receptacles, etc. Ask your CDF man or write for new technical bulletin.

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Bakelite COMPANY • NEWARK 23, DEL.

COMPARATIVE PROPERTIES

Property	Percent Normal Deviation	Commercial Vulcanized Fibre 1/16"	Paper Base (XX) Phenolic 1/16"	VULCOID 1/16"	1/8"	1/4"	1/2"	3/4"	1"
Arc Resistance, seconds	±25	140	4	110	110	110	110	110	110
Specific Gravity	±10	1.25	1.35	1.35	1.35	1.35	1.30	1.20	1.10
Moisture Absorption, % 24 hours	±25	60	1.4	30	15	6	4	4	4 8
Tensile Strength, —MD thousands of psi. CD	±25	11	12 10	12.5 7.5	12 7.5	11 7	9 6.5	8.5 6	5.5 12
Flexural Strength, —MD thousands of psi. CD	±25	16	19 17	24 19	23 17	20 16	16 13	14 11	9 60
Shearing Strength, —MD thousands of psi. CD	±25	8.5 8	14 12	14 12	12.5 11	12 10			
Compressive Strength, flatwise thousands of psi.	±20	25	34	36	36	36			
Izod Impact Strength MD (Edgewise) Ft. lbs. per inch of notch	±20	2.0	0.50*	1.2	1.2	1.2	1.2		
Dielectric Strength, VPM Perpendicular to surface	±20	175	700	475	425	275	170	100	

NOTE: ASTM test methods used for Specific Gravity, Moisture Absorption, Arc Resistance, Tensile, Flexural, Compressive, and Dielectric Strength.

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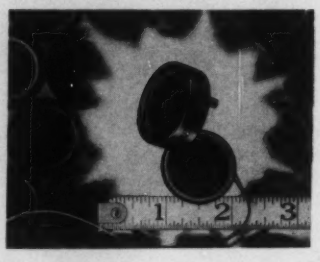
AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS

New Parts

er source which can be used in applications where storage or dry-cell batteries would be used, such as in many portable devices. Cells measuring approximately 1 in. in diam are available in mounted and unmounted types. Mounted cells have black phenolic housings with



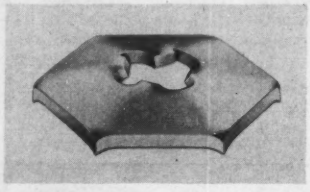
a glass window. Mounting studs also serve as electrical output terminals. Unmounted cells are supplied with attached 6-in. color-coded insulated leads. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 697 on Page 19

Lock Washer

for heavy-duty applications

Design of new high-strength lock washer for heavy-duty applications affords rigidity of assembly, yet provides resilience under extreme loads. The pyramidal lock washer has application wherever high torques are required, such as in locking automobile body bolts. Four and six-sided pyramidal washers



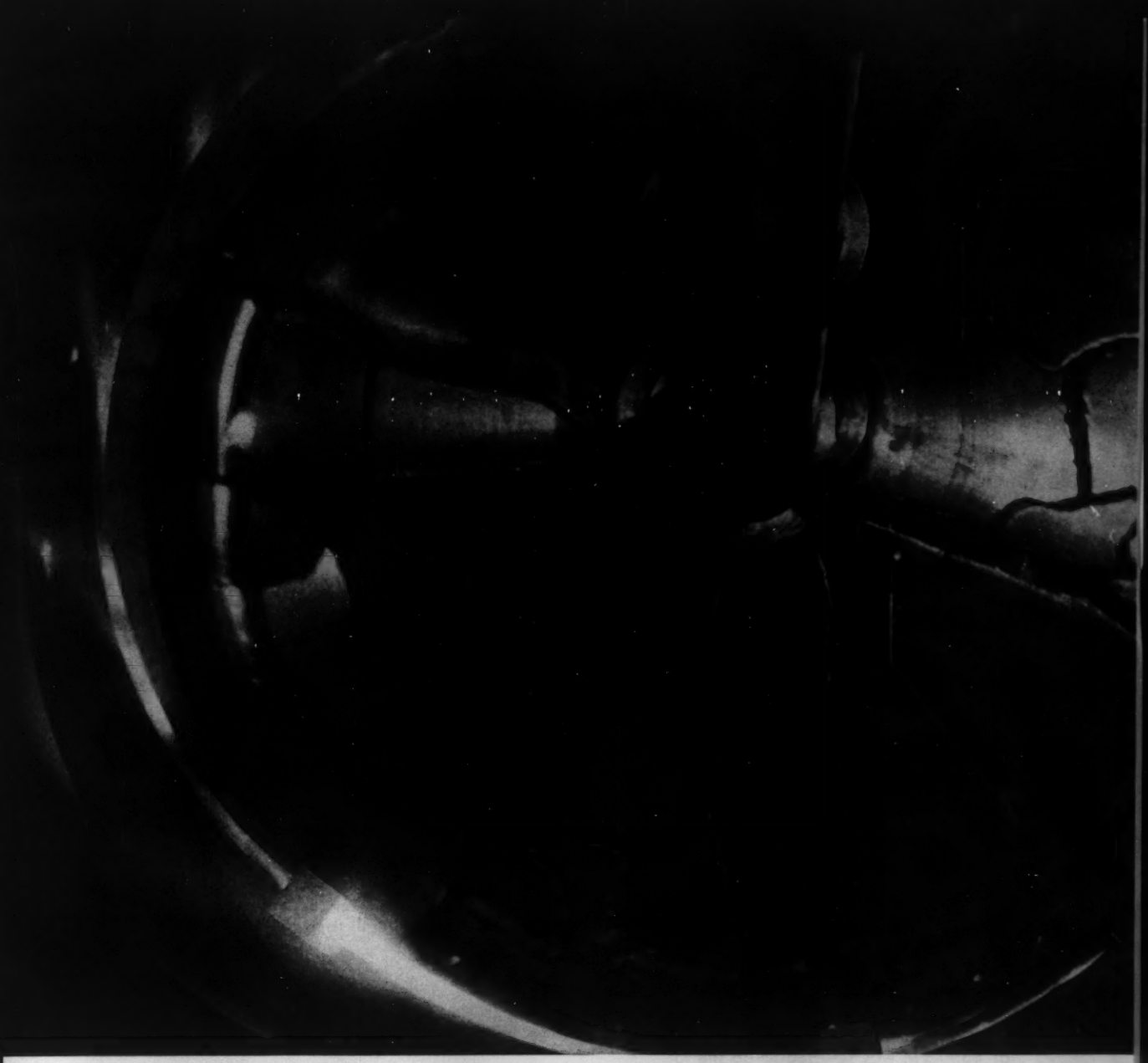
are available in several screw sizes. They can be preassembled onto screws. **Shakeproof Div.**, Illinois Tool Works, St. Charles Rd., Elgin, Ill.

Circle 698 on Page 19

Instant-Reversing Motors

have ratings from 1/6 through 1 hp

Energizing for reversal is instantaneous in Inst-O-Verse motors, because low-friction nylon shoes



This Rem-Cru titanium wheel, whirled at high speed, withstood more stress than the strongest steel.

How strong and tough is titanium?

Part of the answer is shown in a dramatic test, which may illustrate some of the characteristics you are looking for. An 18-pound jet compressor wheel of Rem-Cru C-130 AM titanium alloy was whirled at tremendous speeds. It withstood far more rpm's than the strongest steel. *In fact, this titanium wheel had to be notched before it would break at all.*

If you're looking for a strong, tough metal, with light weight and exceptional corrosion resistance, Rem-Cru titanium is the answer. It's promptly available in the grades and sizes you want.

REM-CRU TITANIUM

World's Most Versatile Metal

Write Dept. MD-12 for the Rem-Cru Review—a free periodical presenting the latest data on titanium.

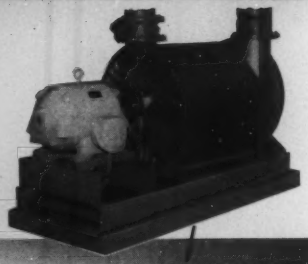
MIDLAND, PENNSYLVANIA

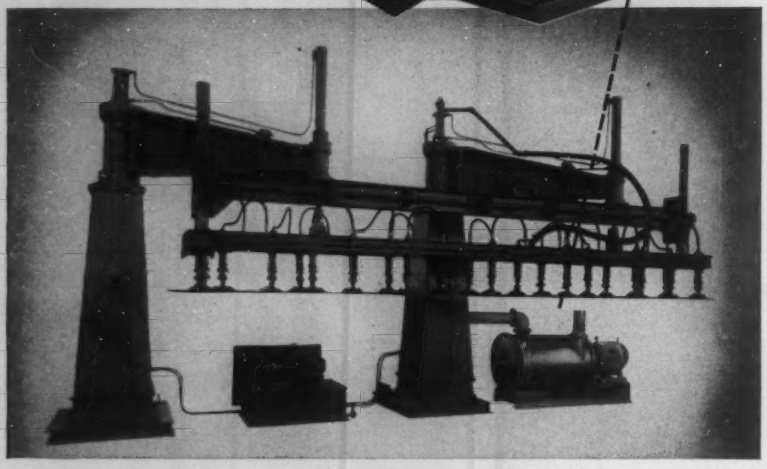
Sales Offices: 6033 East Bandini Boulevard, Los Angeles 22, California • 4501 W. Cortland Street, Chicago 39, Illinois • 405 Lexington Avenue, New York 17, N. Y

Circle 503 on Page 19

SPENCER Vacuum

Supplies the "Muscle" for this machine





Designers at W. S. Rockwell Co. had the problem of developing a machine which would pick up, move and deposit brass sheets of these specifications: weight — 880 lbs.; length — 24′; width — up to 42″; distance of movement — 4′ 6″.

It was decided that the most efficient method of pickup would be suction cup assemblies with vacuum. Obviously, the vacuum producer chosen must be extremely reliable and built to withstand continuous usage.

A 25 H.P., 4 bearing outboard type SPENCER unit rated at 435 CFM was selected to do the job.

Spencer will be glad to cooperate in designing and manufacturing vacuum producers or blowers to meet *your* special requirements.

Two Catalogs to Aid the Designer

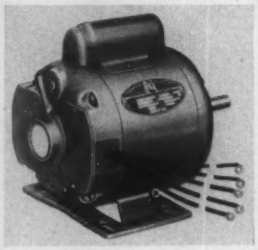
"132 UNUSUAL USES OF SPENCER VACUUM"
Bulletin 144 illustrates and describes how Spencer Vacuum is used in industries from A to Z.

"TURBO DATA BOOK"
Supplies application data on Spencer Blowers. Request Bulletin 107-C.

STANDARD CAPACITIES
of Spencer Vacuum Producers
2 through 400 H.P.
Up to 12" Mercury Vacuum
Volumes up to 17,000 C.F.M.

The SPENCER TURBINE COMPANY
HARTFORD 6, CONNECTICUT

New Parts



fitted to a machined surface on the shaft maintain silver contacts in automatically preset position ready for reversing operation. Reversing power is applied when demanded by manual or automatic transducer, with full torque capacity of the motor instantly utilized. Single-phase, 1725-rpm, 115 or 230-v, sleeve or ball-bearing motors from 1/6 through 1 hp are available. **Franklin Electric Co. Inc.**, Bluffton, Ind.

Circle 699 on Page 19

Miniature Inductors

have wide range and high sensitivity

MF series electrically variable inductors are potted in silicone rubber and are hermetically sealed. Permanent-magnet bias is employed, using ceramic magnets which have been stabilized so that damage by external fields is virtually impossible. Units have wide

range and high sensitivity. They are available for frequencies from 1 to 200 mc. **Vari-L Co. Inc.**, 432 Fairfield Ave., Stamford, Conn.

Circle 700 on Page 19

Flow Meter

has accuracy within one-half of 1 per cent

Bellows - type differential-pressure flow meter is used in conjunction with mechanical recording, indicating, transmission, and control

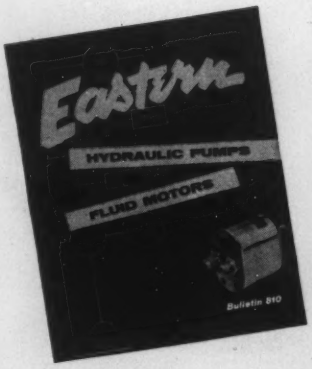
129 Hydraulic Pump and Motor Combinations

Here are power sources for any hydraulic application. Commercial, military, and aviation research have developed this array of standard pump and motor combinations.

With a performance range from .1 to 5 G.P.M. at pressures to 2000 P.S.I., you can expect a stock power source that fits your requirements. Many types of motors offer a choice of electrical characteristics, and have drip-proof, totally enclosed, or explosion-proof enclosures as required.

Typical uses are hydraulic power for machine tools, automatic door openers, material handling equipment, and thousands of other applications requiring smooth, dependable hydraulic power.

When you need custom equipment, call on Eastern and discover how this adaptable line of hydraulic pumps and motors fills the bill without research expense by you.



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Gives full performance data on pump and motor combinations. Write today for your copy of Bulletin 810-A.

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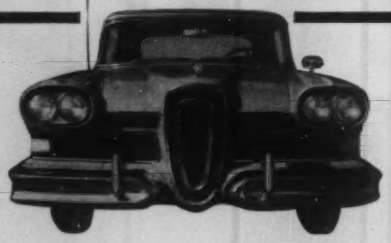
How about Malleable?

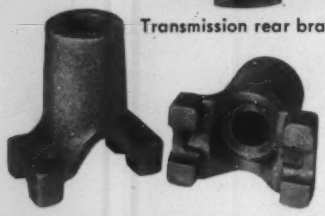


The 1958 Edsel

America's Newest Automobile includes Malleable Iron Castings as important components

Power steering housing

Transmission rear brake drum



Universal joint flange

Recognized for its durability and versatility for over 130 years, and used for parts in all kinds of transportation equipment, it's not surprising to find applications of standard and pearlitic Malleable castings throughout the Edsel.

The three Edsel parts examples illustrated are important uses of malleable. The power steering mechanism housing is certainly a place for safety insurance. The universal joint flange is a vital link in the power train. And the transmission rear brake drum helps complete the flow of engine power to the car's drive wheels.

It's very likely *your* product could be strengthened, lightened or improved by the use of malleable iron castings. And malleable's easy machinability speeds production and cuts costs. A helpful review of *all* malleable iron advantages is contained in our new publication "Value Analysis". Write for your copy — to the Malleable Founders' Society.

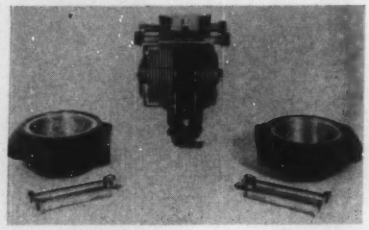
Consult a malleable foundry engineer at the drawing board stage.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building Cleveland 14, Ohio

New Parts

instruments. It is accurate to within one-half of 1 per cent, and maintains accuracy when ambient temperature changes by as much as 100 F and static pressure reaches 2500 psi. Range of the flow meter is changed by springs available in fifteen different ranges between 0-20 and 0-400 in. of water. Ex-



ternal suppression adjustment is available for use when meter body measures liquid level in closed tanks. Unit is shown disassembled. **Minneapolis-Honeywell Regulator Co.**, 2753 Fourth Ave. South, Minneapolis 8, Minn.

Circle 701 on Page 19

High-Strength Metal

can be cast in all forms and shapes

Almanite, which combines austenitic manganese steel and martensitic white irons, can be used in mining, construction, dredging, petroleum, power, foundry, and metalworking industries wherever high wear resistance and hardness are required. The metal can be cast readily in all forms and shapes. Structure is similar to heat-treated steel, and it possesses a better combination of hardness, strength, and resistance to impact than either austenitic manganese steel or martensitic white irons. Certain types of the new metal have tensile strengths of 90,000 psi with ductility approximately 15 per cent. **Meehanite Metal Corp.**, 714 North Ave., New Rochelle, N. Y.

Circle 702 on Page 19

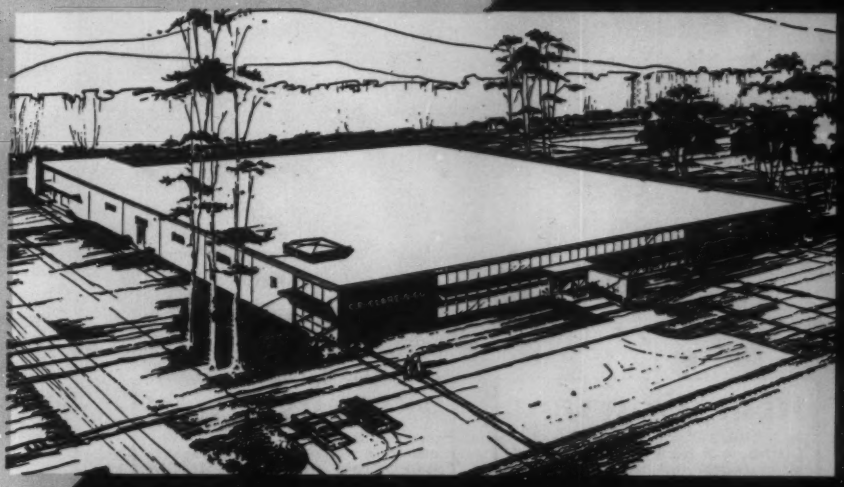
Nylon Balls

in fifteen sizes from 3/32 to ¾ in. diam

Improved Zytel 101 balls are formed by grinding, using a bonded abrasive wheel. Gritfree cool-

Another NEW CLARE PLANT to give you relays of unequaled quality

- Telephone type relays (ac and dc)
- Hermetically sealed relays
- Computer relays
- Video relays
- Power relays
- Mercury-wetted contact relays
- Relay banks
- Plate circuit relays
- Stepping switches
- Lever, push and turn keys
- Other special relays



New C. P. Clare & Co. plant at Fairview, N. C. will expand manufacturing facilities which have been under way in Fairview for two years.

Before midyear 1958 CLARE will be serving customers from a new factory at Fairview, N. C.—a facility that will match the manufacturing advantages of our Chicago plant, itself only five years old.

This CLARE expansion is made necessary by the tremendous growth of the electronics industry and the increasing demand for precise components, including relays whose life can be measured in billions of operations.

Facilities of virtually clinical cleanliness are required for this kind of precision. That's why CLARE plants in both Chicago and Fairview maintain complete control of the temperature, humidity and cleanliness of the air . . . immaculate walls and floors . . . powerful, shadowless lights, for assembly of small parts.

If yours is a product whose long life, reliable performance and freedom from maintenance depends on relays, it will pay you to know ALL about CLARE relays. C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15, Ontario. Cable Address: CLARELAY

CLARE RELAYS

FIRST in the industrial field

Circle 507 on Page 19

Built-in SCALES pre-set machine and check finished product

PRE-SET BY EXACT WEIGHT

In MORRIS PISTON MILLING MACHINE, scale No. 1 determines amount of overweight that must be removed to balance pistons. Linkage transfers reading to depth of cut and sets machine for milling off the correct amount of excess pad.

INSPECTED BY EXACT WEIGHT

After milling, piston travels to the second scale where it is checked against predetermined weight. The SHADOGRAPH scale is adjusted to one gram, plus or minus. Should final check show over or under this amount, machine is automatically stopped.

The above application shows how EXACT WEIGHT precision designed scales can be fitted into modern machine tooling to bring your operations a step nearer automation.

If you are now designing machines or products that require accurately controlled weight as a part of their manufacture, investigate our SHADOGRAPH Scale application. These scales can be easily built into most modern production machines. Their absolute accuracy adapts itself to complete electronic application and control.

Complete engineering data is available for designers. Write, giving your specific application.

Sales and Service Coast to Coast

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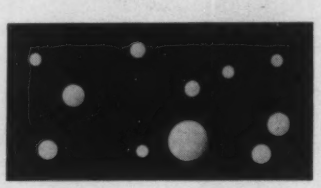
Exact Weight SCALES

THE EXACT WEIGHT SCALE CO.
923 W. FIFTH AVE., COLUMBUS 8, OHIO
In Canada: P.O. Box 179, Station S, Toronto 18, Ont.

BETTER QUALITY CONTROL . . . BETTER COST CONTROL

New Parts



ant prevents ball surfaces from accumulating foreign particles. Clear Nylon balls are available in fifteen standard sizes from 3/32 to ¾ in. diam. **Industrial Techtonics Inc.**, 3686 Jackson Rd., Ann Arbor, Mich.

Circle 703 on Page 19

V-Belt Pulley

for fractional-horsepower applications

Step-down V-belt pulley is made entirely from welded pressed-steel parts. It is for fractional-horsepower use on appliances and similar equipment. Construction offers light weight, rigidity, and eliminates solid metal machined hub. One section of the larger pulley is formed to make the inner

half of the step-down pulley, adding to the strength and rigidity of the entire unit. **Nagel-Chase Mfg. Co.**, 2809 N. Ashland Ave., Chicago 13, Ill.

Circle 704 on Page 19

Captive Fastener

for use on electronic subassemblies

New captive fastener, adapted for use on electronic subassemblies, consists of a swaged-in-place sleeve, a bolt with both threaded shoulder and shaft, and a small spring. Two threads at the top of the sleeve accommodate the threaded shoulder of the bolt. Two turns of the bolt carry it through the threads to become captive within the sleeve, held in place by

TENSION - TO KEEP YOUR BOLTED ASSEMBLIES TIGHTER LONGER

Wherever products are subject to movement, vibration, stresses and strains, more than tight fastenings are necessary to keep assemblies tight indefinitely. There must be constant tension in the assemblies and the one sure way to accomplish this is by the use of famous Reliance Spring Lock Washers. They not only retard "nut creep," but automatically compensate for bolt stretch, thread wear, expansion and contraction due to temperature changes.

Made of cold drawn spring steel in Reliance's own cold finished mill, the Spring Lock Washers are quality controlled throughout their manufacture and offer the reactive range and pressure necessary to keep bolted assemblies tighter longer. Reliance Spring Lock Washers have proved for fifty years an accepted standard in industry, and are produced in four standard series: light, medium, heavy and extra heavy for each screw and bolt size.

For more information please write for Engineering Bulletin W-50 or request a visit from one of our fastening engineers.

EATON

RELIANCE DIVISION
MANUFACTURING COMPANY
506 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Montreal

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

Specifications for WARREN'S *NEW* Flange Mounted Rotex Pump

FLANGE MOUNTED OIL PUMP

RANGE

1. From 5 to 750 g.p.m. dependent upon speed.
2. Discharge pressure to 300 p.s.i.g. dependent upon pump size.

MATERIALS

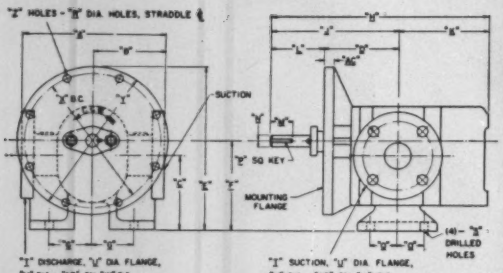
Standard construction All Iron. Ductile Iron or Steel available for applications involving thermal or physical shock.

FEATURES

1. High volumetric efficiency permits wide range of speeds.
2. Timing Gears allow high speed operation at low pitch line velocities eliminating danger of cavitation.
3. Self-priming possible because of close internal clearances.
4. Available with either Mechanical Seal or Conventional Stuffing Box.

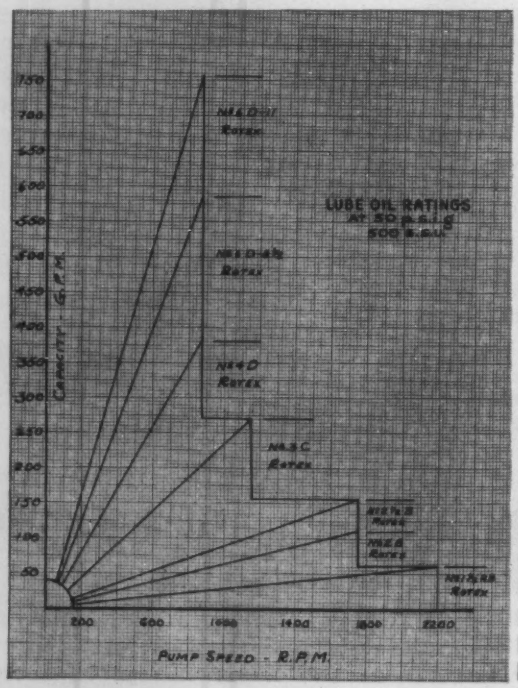
APPLICATIONS

Diesel Engines
Gasoline Engines
Reduction Gears
Turbines
Hydraulic Systems
Machine Tools



G-H ROTEX PUMP NO	REFERENCE LETTER A	B	C	D	E	F	G	H	J	K	L	M	N
1½ AB	8	4	4¼	4⅜	8 15/16	5 1/16	2⅜	12¼	7⅞	4 13/16	3 1/16	1¼	6873 6870
2B	11	5½	5 3/16	5⅜	9⅜	4⅜	3 11/16	14⅜	8¾	5 9/16	3⅜	1¼	9373 9370
2½B	11	5½	5 3/16	6⅛	9⅜	4⅜	3 11/16	15⅛	9½	6⅜	3⅜	1¼	9375 9370
3C	13	6½	5 15/32	7⅜	14⅜	6⅜	4½	21¾	13⅛	8⅜	5½	1¾	12500 12493
4D	16⅜	8 1/16	6⅞	8½	16½	9	6 1/16	23½	13¾	9½	5¼	2¼	14375 14370
6D-8½	16⅜	8 1/16	5 11/16	10	16½	9	6⅜	26¼	15¼	11	5¼	2	14375 14370
6D-11	16⅜	8 1/16	5 11/16	11¼	16½	9	6⅜	28 11/16	16 7/16	12¼	5 5/16	2¾	14375 14370

G-H ROTEX PUMP NO	REFERENCE LETTER P	Q	R	S	T	U	V	W	X	Y	Z	AB	AC
1½ AB	3/16	1½	3/4	7/16	1½	5	3/8	3¾	6	7½	4	(4) HOLES	3/8
2B	1/4	2⅛	1	9 16	2	6	3/8-11	4¾	8¼	10	4	(4) STUDS	1/2
2½B	1/4	2⅞	1	9 16	2½	7	3/8-11	5½	8½	10	4	(4) STUDS	1/2
3C	1/4	3½	1	3/4	3	7½	3/8-11	6	13	15	8	(4) STUDS	1/2
4D	3/16	4¾	1	13 16	4	9	3/8-11	7½	13	15	8	(8) STUDS	5/8
6D-8½	3/8	6¼	1	1 1/16	6	11	1/2-10	9½	13	15	8	(8) STUDS	5/8
6D-11	3/8	7½	1	13 16	6	11	3/4-10	9½	13	15	8	(8) STUDS	5/8



WARREN PUMPS, INC.
WARREN MASS.

G-6

New Parts

a small tension spring. Subassembly can then be fastened tightly to a major assembly by turning bolt into tapped holes or other mating fasteners until bolt tightens on a shoulder in lower part of

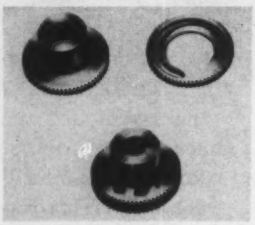
sleeve. Bolt has a hexagonal, slotted head, permitting use of screwdriver or wrench to attach or detach subassembly. **Moran Co.**, 115 Main St., El Segundo, Calif.

Circle 705 on Page 19

Miniature Gears

in solid pin and clamp-type hubs

Dynaco Precision Class I and Class II antibacklash gears are available in six diametral pitches from ⅝ to 1 in. OD. Both solid-pin and clamp-type hubs are furnished, in three different bore sizes. Gears



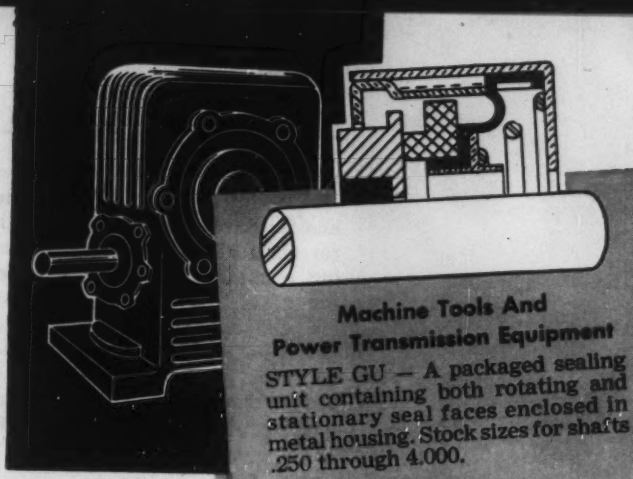
have an internal helical spring. **Dynamic Gear Co. Inc.**, 20 Merrick Rd., Amityville, N. Y.

Circle 706 on Page 19

Teflon Tubing

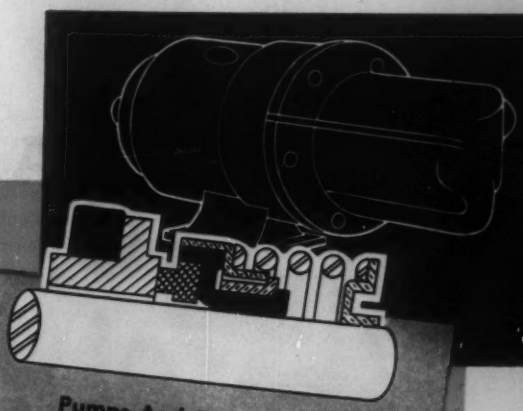
for chemical and electrical applications

Polypenco thin-wall Teflon tubing is available in 11 sizes from ⅛ to 1 in. ID. Nominal wall thicknesses are 0.030 in. on sizes through ⅝ in., 0.040 in. on ¾-in. size, 0.045 in. on ⅞-in. size, and 0.050 in. on 1-in. size. All sizes are available in ten coded colors for circuit iden-



Machine Tools And Power Transmission Equipment

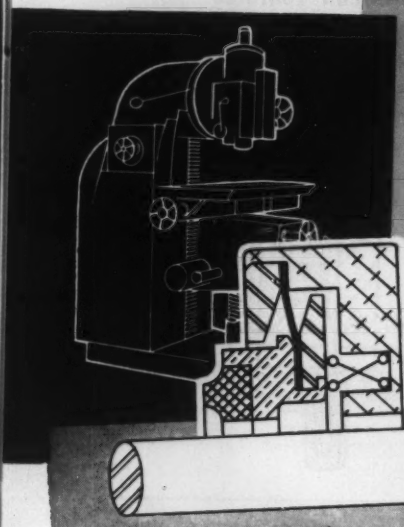
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

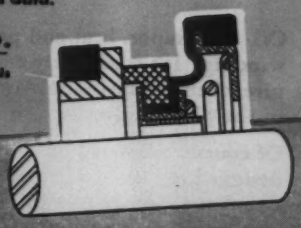
A Complete Line GITS SHAFT SEALS For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

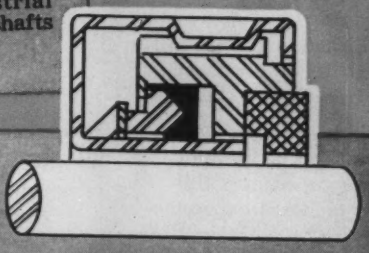
1868-A South Kilbourn Avenue • Chicago 22, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



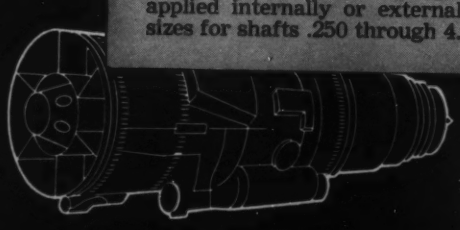
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



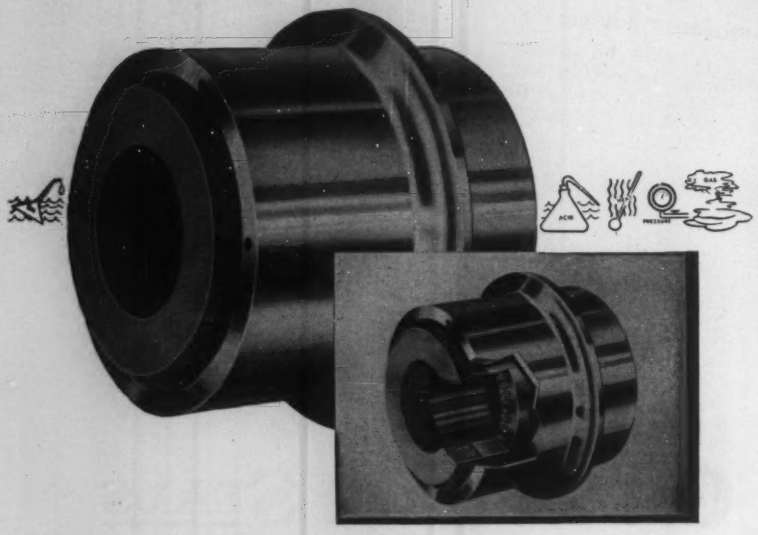
Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



Circle 511 on Page 19

SPECIAL



nothing can touch this winding

Oil, acid, vapor, heat and pressure don't affect this AC motor winding. It's completely encased in a special, high-temperature, chemical-resistant plastic. The windings are cast right in the plastic to make a single, solid, impervious piece.

Of course, this winding goes into a special motor — one that's designed to run in a pressurized atmosphere of inert gas, under constant exposure to a piping-hot oil splash and vapor at over 200°F. Temperature-stabilized bearings, oil lubricated under pressure, and drip-proof, corrosion-resistant construction are some other design necessities for this unique 115-volt, 1/3 hp AC motor.

Here is a typical example of ESCO's unusual ability to design and build rotary electrical equipment to meet special customer needs. Whether or not your particular motor problem is this special, remember that ESCO's twenty years of broad experience is always available to you. No motor or generator problem is too big or small, too routine or specialized for ESCO engineers and craftsmen to solve properly, the way you want it solved.

Refer to Esco Catalog in section $\frac{4a}{E1}$ in Sweet's Product Design File, or write direct for general catalog No. 56PD. Why not also send us details on your special problem . . . we'll be glad to show you how we would go about solving it for you.

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.

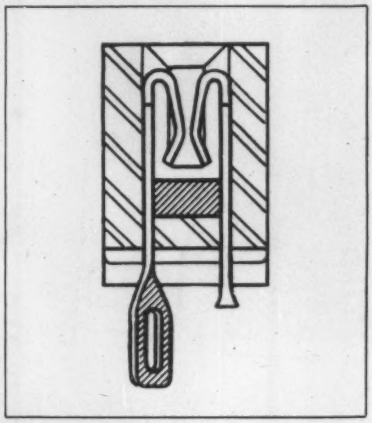
New Parts

tification. Uses include chemical and food-processing lines. Tubing has excellent dielectric properties for use for wire bundling or sleeving insulation. It resists soldering heats, has high flex life, and low and high-frequency insulating properties are virtually unaffected by moisture or heat to 500 F. **Polymer Corp. of Pennsylvania,** 2140 Fairmont Ave., Reading, Pa.

Circle 707 on Page 19

Printed-Circuit Contacts

have high flexing strength



Swingflex contacts, which have high flexing strength and positive area contact, are for use with printed-circuit boards 1/16 and 3/32 in. thick. They are for either single or double-sided board connection. Design eliminates the possibility of damage to contact or printed-circuit board during assembly or multiple insertion. Contacts are pretempered beryllium copper, available in solder-eye (shown), taper-tab, solder-dip, and wire-wrap terminations. **H. H. Buggie Inc.,** Box 817, Toledo 1, Ohio.

Circle 708 on Page 19

Miniature Pump

for airborne cooling installations

Model 1733-HBU-249 coolant pump is a self-priming, positive-displacement unit with an externally adjustable pressure-regulating valve. It is for use in supersonic, high-altitude flight and meets military

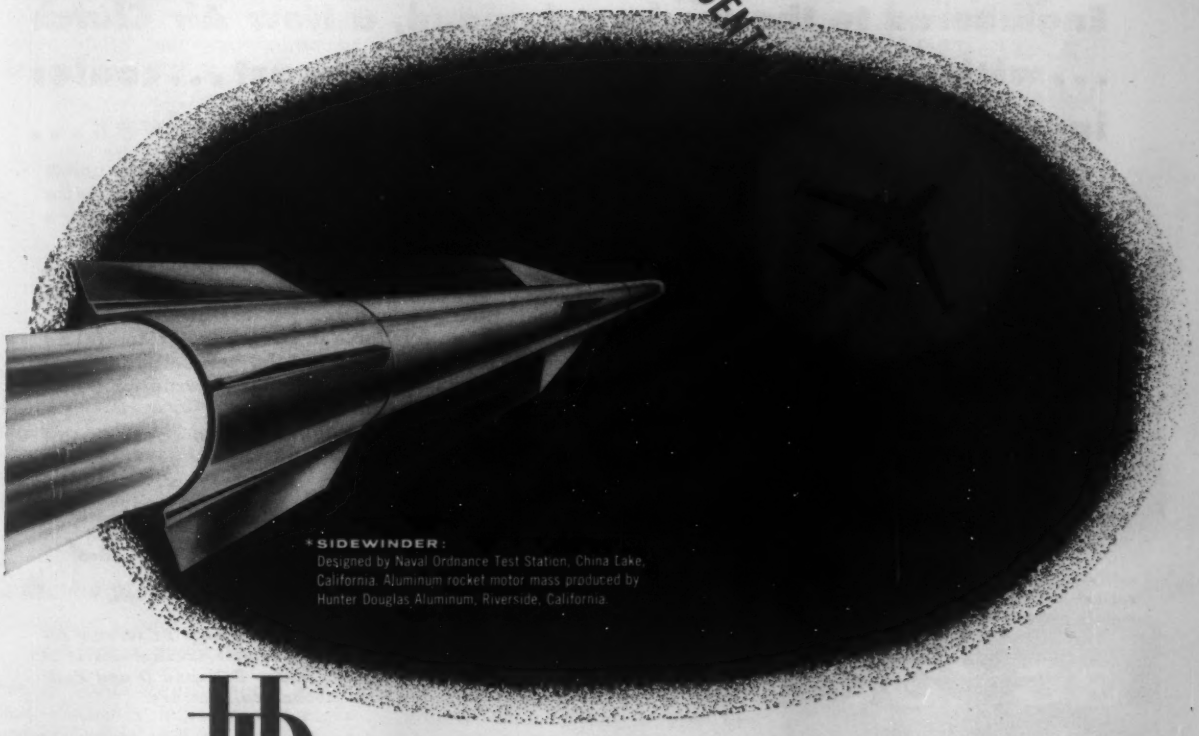
THE SKY TUBE THAT STAYS HOT ON A HEAT "SCEN

In the skies today flies a new series of deadly, pilotless rockets...lethal in their sting, unerring in their flight. Infrared control solved the major problem of guidance but mass production of the rocket with economy was still a difficult assignment. Here, Hunter Douglas aluminum cold forgings proved uniquely successful.

This process achieves fast, economical production of tubular shapes with a variety of internal and external structural details integral with the tube itself. Costly fabrication and time-wasting assemblies are eliminated. The resulting tubes are *stronger, simpler, cheaper, more accurate* and *more efficient!* Combine these advantages with *straightness, roundness* and *true diameter* from end to end and you'll see why Hunter Douglas is the recognized source for cold forged tubular components from coast to coast.

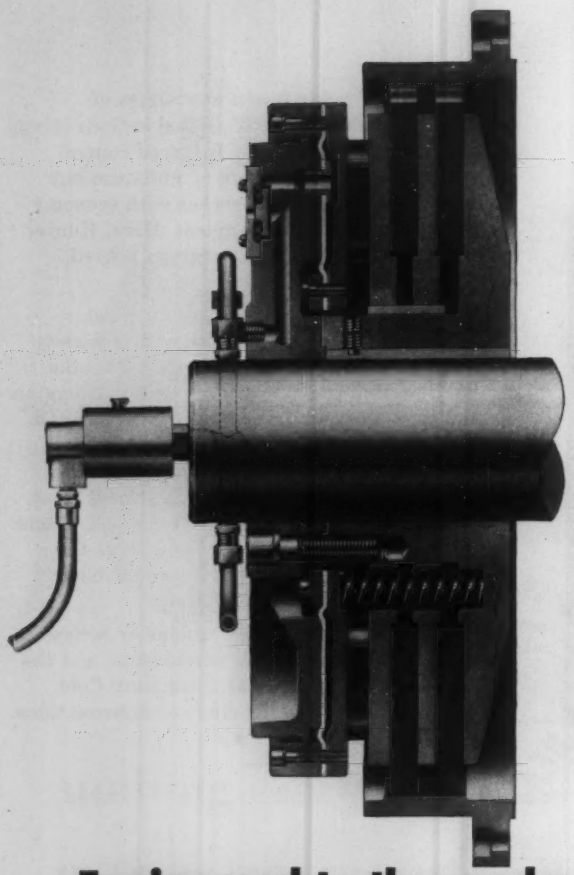
If your contract includes tubular or hollow shapes—with or without closed ends—get the facts on Hunter Douglas Aluminum Cold Forgings. A letter will bring recommendations.

ANOTHER HUNTER DOUGLAS "FIRST"—*Newest member of the special metals family to undergo successful cold forging at Hunter Douglas is Molybdenum—now produced experimentally in precision tubes of nominal length. Not a standard production item; cost necessarily restricts Moly tubes to vital projects, at present.*



*SIDEWINDER:
Designed by Naval Ordnance Test Station, China Lake, California. Aluminum rocket motor mass produced by Hunter Douglas Aluminum, Riverside, California.

Hunter Douglas Aluminum Division of Bridgeport Brass Company • Dept. MD12 Riverside, California • OVerland 3-3030



DODGE AIR-GRIP CLUTCH

Engineered to the modern demand, a *New Air Clutch* ...with amazing sensitivity...compact...cooler in operation...built-in quick release valves...

Finger tips on the throttle bring instant response, give the operator split-second control. This new product of Dodge is the quickest-acting air clutch available!

New design and engineering by Dodge achieve this exceptional control—in a clutch that provides maximum torque capacity in minimum space. Less air is used to operate the clutch—the result is a new sensitivity that enables the operator to "inch" the clutch, or to throw it into full engagement as required. Where instant disengagement is needed, quick release valves are built into the clutch itself, as optional equipment.

The unique design of the Air-Grip Clutch places the air seal disc at the end *farthest* from the pressure plates, which generate the heat inherent in clutch operation. This, combined with automatic internal ventilation, insures cooler operation and longer life under severest service. Provision is made for mechanical engagement of the clutch if the air supply should fail.

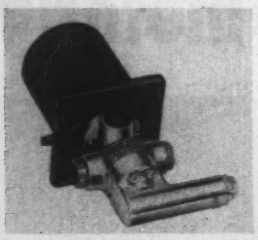
Thorough tests in the field as well as in the laboratory assure you of Dodge dependability in the Air-Grip Clutch. Available in sizes from 8.5 to 460 hp at 100 rpm at 80 psi. Call your local Dodge Distributor or write for Bulletin A634.

DODGE MANUFACTURING CORPORATION
3300 UNION STREET, MISHAWAKA, INDIANA

DODGE
of Mishawaka, Ind.

Sixty years of experience in serving industry's clutch needs... manufacturer of the famous Dodge Diamond D and Rolling Grip mechanical clutches.

Call the Transmissioneer, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified telephone directory, or write us.



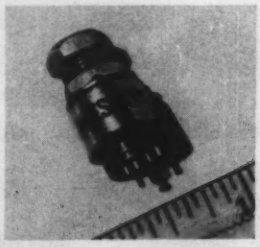
specifications requiring 1 gpm at 100 psi of ethylene glycol and water. Pump permits the design of airborne electronic cooling systems. It is flange mounted so that the motor can be inserted directly into the cooling-air duct, using airflow to cool the motor, thereby reducing weight and size. Maximum dimensions are 3 x 3 x 7 3/16 in., and weight is 3 lb 9 oz. **Eastern Industries Inc.,** 100 Skiff St., Hamden 14, Conn.

Circle 709 on Page 19

Miniature Potentiometers

dissipate 2 w at 60 C

Microminiature precision wirewound potentiometers known as Acesets, are available in nine resistance values between 100 and 25,000 ohms. They offer high stability under temperature cycling, and dissipate 2 w at 60 C. Units



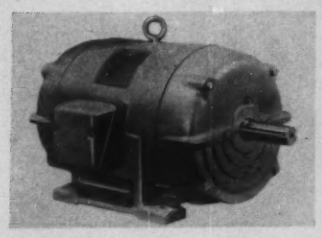
incorporate a one-piece, precision-machined metal case, passivated stainless-steel shaft, and self-contained locking device. Resistance tolerance is ±10 per cent. **Ace Electronics Associates Inc.,** 99 Dover St., Somerville, Mass.

Circle 710 on Page 19

Induction Motor

compact ac unit is for synchronous applications

Syncro-Spede synchronous induction motor is built in the same NEMA frame size as a standard motor of equal horsepower. It accelerates as an induction motor, but runs at exact synchronous speed without permanent magnets or dc excitation. A compact ac unit, it offers high power factor and efficiency, and is suitable for use on many applications requiring constant speed with varying load. Since it is unaffected by voltage fluctuations, it is suitable for precision timing and metering devices and for recording instru-



ments. Unit is available in ratings from 1 to 100 hp in any enclosure, and can be foot or flange mounted. **Louis Allis Co.,** Dept. P, 427 E. Stewart St., Milwaukee 1, Wis.

Circle 711 on Page 19

Ceramoplastic

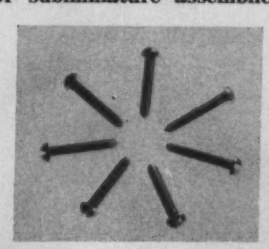
resists temperatures to 1600 F

Supramica 560 is formulated from synthetic mica, which increases the temperature resistance of the ceramoplastic. It can be used for applications requiring excellent insulating properties and continuous operation at temperatures to 950 F. Material retains its structural characteristics at temperatures as high as 1600 F. **Mycalex Corp. of America,** Clifton Blvd., Clifton, N. J.

Circle 712 on Page 19

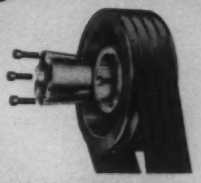
Black Nylon Screws

for subminiature assemblies



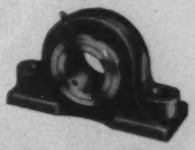
Molded black nylon screws are available in 2-56 round-head size.

(*Please turn to Page 214*)



TAPER-LOCK
SHEAVES
Easy on — easy off! Mount flush!

TAPER-LOCK
SPROCKETS
No reboring — no waiting!



SC AND SCM
BALL BEARING PILLOW BLOCKS
"The seal won't blow!"

●

Write for Bulletins!

- Taper-Lock Sheaves. Drive tables and technical data. Bulletin A-661
- Taper-Lock Sprocket and Dodge Roller Chain data. Bulletin A-644
- Rolling Bearings—SC, SCM and Dodge-Timken. Bulletin A-638

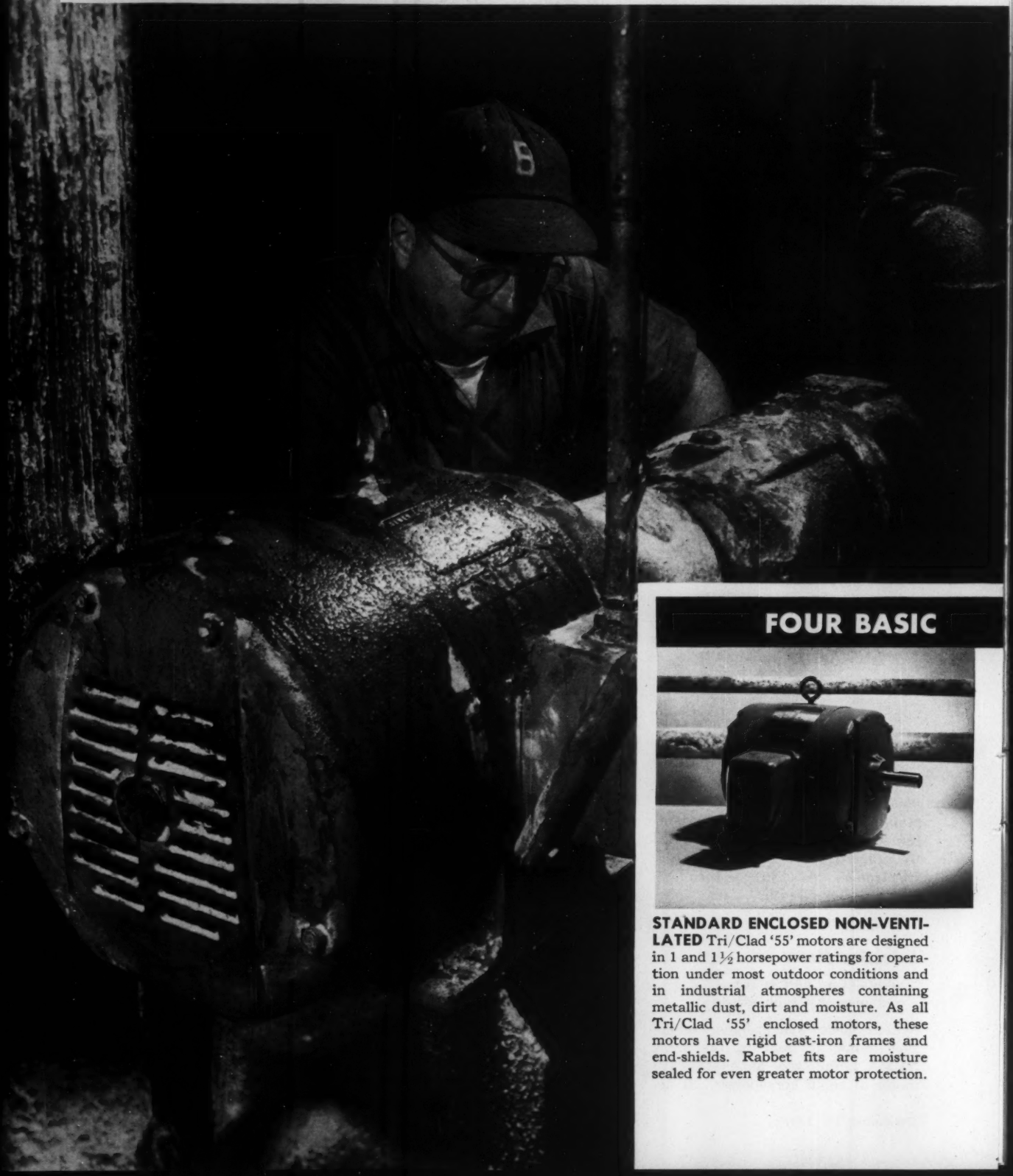
DODGE MANUFACTURING CORPORATION
3300 Union Street • Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

Circle 515 on Page 19

There's a G-E TRI 55 CLAD motor for

REG. U.S. PAT. OFF.



FOUR BASIC

STANDARD ENCLOSED NON-VENTILATED Tri/Clad '55' motors are designed in 1 and 1½ horsepower ratings for operation under most outdoor conditions and in industrial atmospheres containing metallic dust, dirt and moisture. As all Tri/Clad '55' enclosed motors, these motors have rigid cast-iron frames and end-shields. Rabbet fits are moisture sealed for even greater motor protection.

your toughest applications!

General Electric announces new severe-duty enclosed motors in ratings from 1 to 5 horsepower, giving you a more complete line of Tri/Clad '55' enclosed motors to choose from.

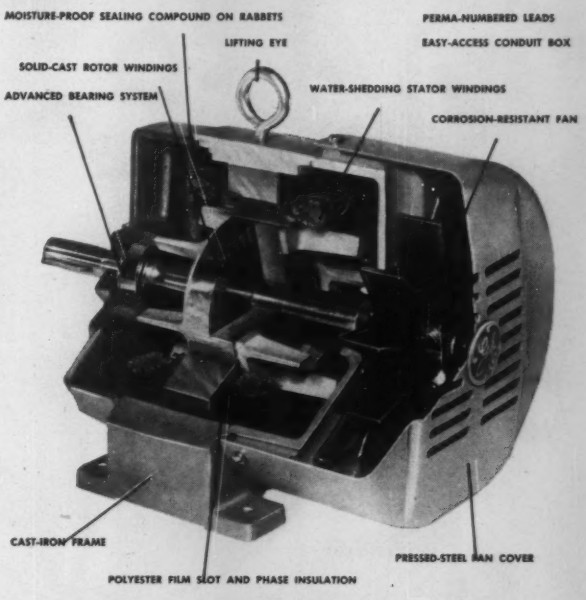
Whether you need a standard enclosed, severe-duty, or explosion-proof motor, General Electric has the rating you need. From G.E.'s complete line—the most complete in the industry—you are better assured of getting the "right" motor for your toughest applications.

Of course, G-E enclosed motors offer you all the outstanding features of the Tri/Clad '55' line including Mylar* polyester film insulation for longer life, minimum maintenance; non-wicking leads and silicone stator coating for maximum moisture protection; Formex† magnet wire for greater protection against heat-aging and abrasive dust; and many, many more.

Because they're built for better protection, longer life, easier installation and minimum maintenance: G-E Tri/Clad '55' *totally* enclosed motors are your best buy.

For more information on the "right" motor for your applications, contact your G-E Apparatus Sales Office or Distributor. Or, write to Section 840-8, General Electric Company, Schenectady, N. Y. for bulletins GEA-5980 and GEA-6341. For enclosed motors above 5 hp, ask for GEA-6602.

*Registered Trade-mark of the DuPont Co.
†Registered Trade-mark of the General Electric Co.

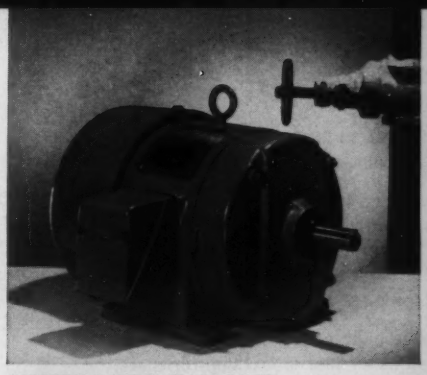


Standard enclosed fan-cooled Tri/Clad '55' motor.

GENERAL ELECTRIC

TRI 55 CLAD ENCLOSED MOTORS AND WHERE TO USE THEM

STANDARD ENCLOSED FAN-COOLED Tri/Clad '55' motors, designed for operation under the same conditions specified for the standard enclosed non-ventilated motors, are available in ratings from 2 to 5 horsepower. Features include rugged, pressed-steel fan cover; non-sparking fan; and pressed-steel conduit box with keyhole slots for all-position mounting.



SEVERE-DUTY ENCLOSED Tri/Clad '55' motors are available in both fan-cooled and non-ventilated designs for applications in chemical atmospheres and other areas in which highly corrosive or excessively moist conditions are encountered. Available in ratings from 1 through 5 horsepower, General Electric severe-duty motors feature all cast-iron construction, external neoprene slinger, and complete gasketing for greater motor protection.

EXPLOSION-PROOF Tri/Clad '55' motors are designed for safer operation in atmospheres containing gases or dust which threaten explosion or serious damage in the event of an electrical spark. G-E explosion-proof motors are U. L. listed, and each feature a non-sparking fan; long, close rabbet fits; sealed lead entrance; and dust-tight labyrinth shaft seal.

Circle 516 on Page 19

SOUND THE CALL FOR **NBD BRONZE**

Any shape! Any weight up to 20,000 lbs. As-cast, semi-machined or finish-machined.

That's what we offer when you call for pump housings, bushings, impellers . . . of NBD Bronze. Many leading manufacturers like the combination . . . find cost-saving benefits in our more than 40 specially-developed bronze alloys and knowledge of casting techniques.

We're fully equipped to handle your largest requirements, as well as smaller production-run sizes. Shell mold, cast-to-size, centrifugal casting are also right down our alley.

Call or write for quote or information.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

717 Grant Building • Pittsburgh 19, Pennsylvania

PLANTS IN: CHICAGO • ST. LOUIS • MEADVILLE, PA.

New Parts

(*Continued from Page 211*)

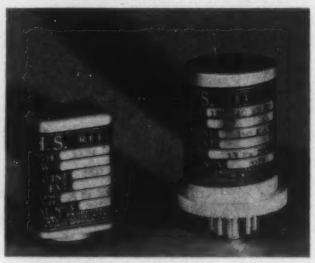
They are suitable for subminiature assemblies and other small components. Screws are nonmagnetic and retain toughness over a wide range of temperatures. **Weckesser Co.,** Dept. MDC, 5701 Northwest Highway, Chicago 30, Ill.

Circle 713 on Page 19

Meter-Relay

withstands shock and vibration to 20 g

Redesigned Model 126 VHS meter-relay (left) is smaller, more resistant to resonance under vibration, and more reliable than its predecessor. It is actuated by electrical changes as small as 0.2 ma or 0.1 mv, and withstands shock and vibration to 20 g. Measuring 1 x 1¼ x 1⅞ in., it functions in tem-



peratures from −50 to 150 F. Sensitivities extend to 10 amp or 500 v. Shell is an accurate casting of sintered powder iron, and requires no machining. Bracket is an investment casting of beryllium copper. Indicating pointer is part of a single stamping with four arms, one of them serving as the pointer. Base and movement are rigidly fastened together. **Assembly Products Inc.,** Wilson Mills Rd., Chesterland, Ohio.

Circle 714 on Page 19

Photoelectric Scanners

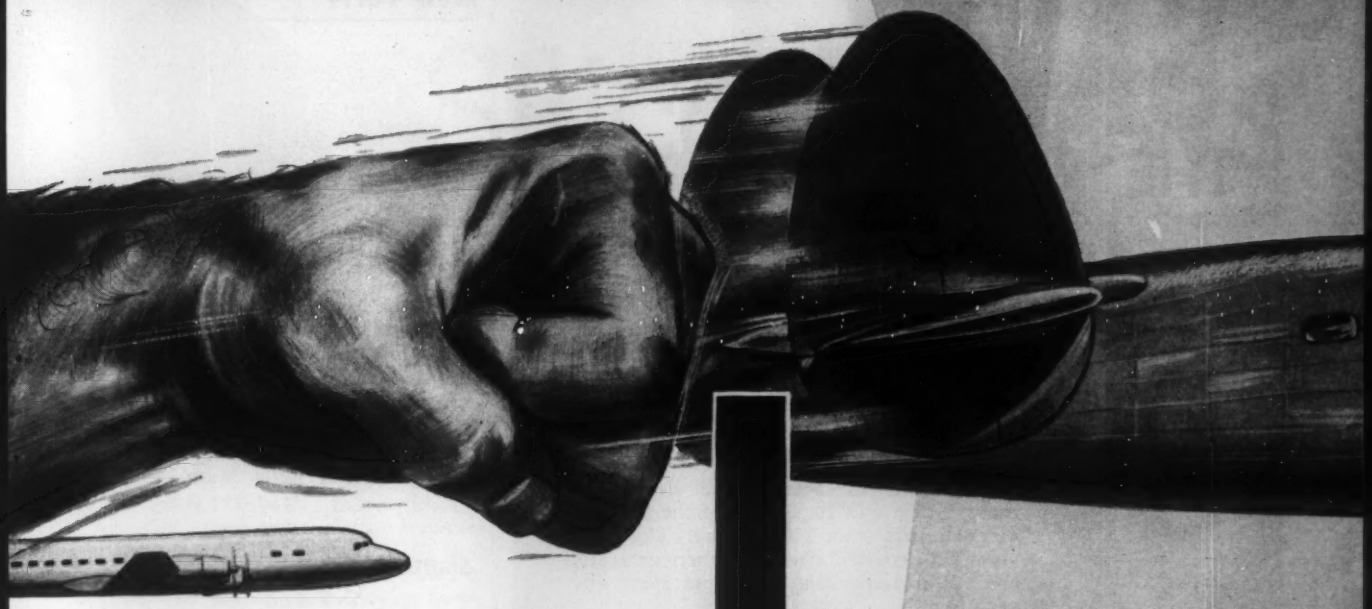
miniature units are operated by very small objects

Miniature photoelectric scanners provide whole-light-beam interruption by 1/32 in. diam objects, moving at a fast rate. Heads can be installed in a space 2 to 12 in. apart. Photocell responds to reflected and direct light. Light source operates on 6.3 v, and beam has adjustable focus for sharp defi-

Circle 517 on Page 19

Circle 518 on Page 19→

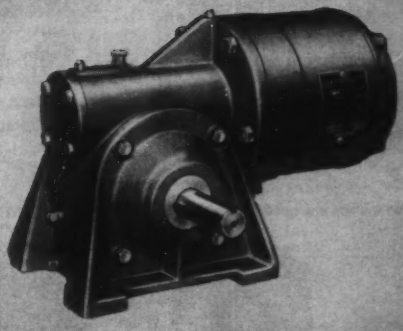
WHERE POWER CONTROL COUNTS MOST...



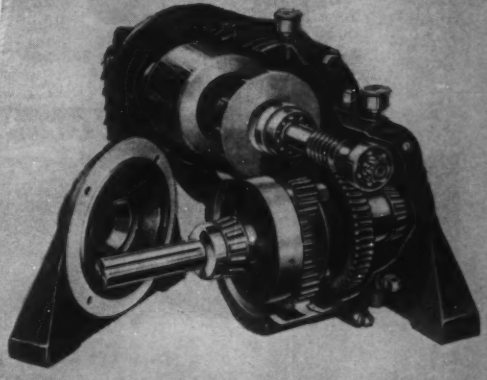
...you'll find Janette

When perfect power control is essential, engineers specify Janette gear motors, speed reducers, and variable speed control drives, because they are integral units—motor and gears are designed for each other—then built by one company to assure perfect reliability, extra long, trouble-free life.

Regardless of the product, Janette has the right speed at the right power for your particular application from 1/150 to 7½ horsepower, in a wide variety of models and in any mounting position. And when your problem demands original research and custom design, you can draw on the nearly 50 years of Janette engineering experience and know-how.



GEAR MOTORS • SPEED REDUCERS



For additional information you are invited to write for bulletin 5-105-M6

Janette ELECTRIC MFG. CO.
MORTON GROVE, ILLINOIS

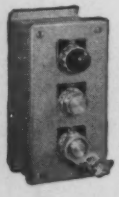
REPRESENTATIVES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

SAVE! WITH THE RIGHT CONTROL

There is a *right* Furnas Electric control for every job. Cost and space advantage can be yours by choosing the control designed for the motor.

Furnas Magnetic Starters are available through Size 4 in 10, instead of the usual 5, different sizes from 1 to 100 hp. This provides "In-Between" sizes, not otherwise available, at corresponding price and space advantages.

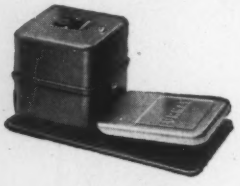
Drum Controllers—over 1000 models available from 1 to 10 hp. for whatever application you require.



Oil Tight Push Buttons for every need. Standardization and interchangeability mean more combinations with fewer parts. Complete accessory line.

Pressure Switches

Limit Switches



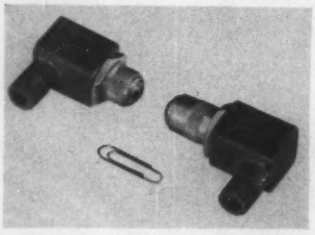
Foot Switches

FOR MORE INFORMATION WRITE FOR BULLETIN 5411, 1045 McKEE ST., BATAVIA, ILLINOIS

A28

FURNAS ELECTRIC COMPANY
BATAVIA, ILLINOIS
SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

New Parts



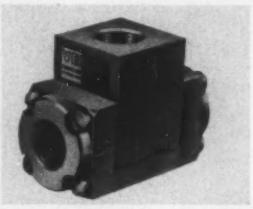
nition of light source. Two types of miniature photocells are available for the light-pickup head. Three general types of response are possible by choice of electronic relays. **Farmer Electric Products Co. Inc.**, 2300 Washington St., Newton Lower Falls, Mass.

Circle 715 on Page 19

Shuttle Valve

in four sizes from 1/8 to 1/2 in. NPT

This shuttle valve provides for the charging and discharging of pressure cylinders through the actuation of any one of two or more three-way valves located at remote-control stations. It prevents air from the valve that is being actuated from being vented to the atmosphere through the exhaust ports of the nonactuated valves. O-ring seals are airtight and cannot be cut in the normal operating



pressure range. Valve is available in 1/8, 1/4, 3/8, and 1/2-in. NPT sizes, for pneumatic or hydraulic control. It has threaded ports, and flow direction is marked to facilitate installation. **Versa Products Co. Inc.**, 249 Scholes St., Brooklyn 6, N. Y.

Circle 716 on Page 19

Synthetic Seal

for tapered roller bearings

Duo-Face seal combines the features of an outside-diameter seal and a face-type seal. One lip op-

Circle 519 on Page 19

Circle 520 on Page 19→

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 45

New "Shape-it-yourself" Silastic Vulcanizes at Room Temperature

A new, room temperature vulcanizing silicone rubber with excellent handling characteristics and durability is now available from Dow Corning.

The new rubber, Silastic* RTV 501, stays rubbery from —70 to 500 F and has exceptional resistance to moisture and weather. These and the other properties shown below make Silastic RTV 501 ideal for encapsulating electric and electronic assemblies and for general potting, sealing and calking applications.

Easy to process, the new silicone rubber has a long shelf life and mixes easily with the recommended catalyst. The two ingredients can be blended either manually or mechanically as long as three hours before being used. Both the fluid polymer and catalyst have a viscosity of approximately 60,000 centistokes. Silastic RTV 501 cures at room temperatures within 24 hours and attains maximum physical properties in only 2 to 3 days. *No. 456*

Typical Properties of Silastic RTV 501	
Serviceable temperature range	—70 to 500 F
Electric strength, volts/mil	300 to 500
Dielectric constant, 10^2 cycles per second	2.6
Dissipation factor, 10^2 cycles per second	0.01
Water absorption after 70 hours at 212 F, percent	Nil

*T. M. REG. U. S. PAT. OFF.

SILICONE ADHESIVES AID DEVELOPMENT OF PRESSURE-SENSITIVE TEFLON TAPES

With the aid of Dow Corning 274 Adhesive, the first pressure-sensitive adhesive ever developed that will stick to Teflon, Minnesota Mining has introduced a new Teflon-coated "Scotch" brand tape with a wide field of potential applications.

Applied to main carrying rollers on machines making heavily sized papers, for example, this new 3M tape promises to eliminate one of the "stickiest" problems in the paper industry. Sizing accumulates on these rolls so rapidly that repeated shutdowns are necessary to clean them before the paper is ruined, or before the build-up hardens and must be chiseled off.

Now, however, by simply half-lap wrapping the steel rollers with the new Teflon-silicone adhesive tape, the sizing is repelled and maintenance costs reduced.

The effectiveness of this wrapping, which adds only 3 to 6 mils thickness, is demonstrated in the photo above. Note how the lead carrying roller on the right, wrapped with tape a year ago, is still as clean as a whistle. In contrast, the steel-surface roller is almost completely covered with sizing even though it occupies a less vulnerable position in the line-up.

Coating the steel rollers directly with Teflon would produce a similar effect but at a prohibitive cost. The 3M tape is so economical that in some cases it has paid for itself in a single day's run!

Facts about Dow Corning silicone adhesives: Because of their semi-inorganic nature, silicone adhesives have many unusual properties. Pressure-sensitive tapes based on them stick to almost anything including wet surfaces. Silicone adhesives possess good strength, are superb electrical

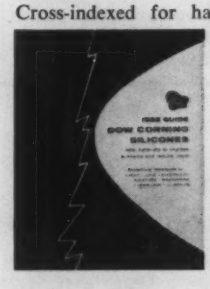
(*Cont. Pg. 2*)

ALL-NEW REFERENCE GUIDE TO SILICONE PRODUCTS NOW AVAILABLE

Most complete reference guide to silicones ever produced, describes Dow Corning silicone products now available in commercial quantities: fluids, lubricants, resins, adhesives, varnishes, dielectrics, rubber, water repellents, textile finishes, leather treatments, and other specialized forms.

Its 16 pages are filled with data and illustrations suggesting ways in which you can cut costs, simplify designs, improve performance and add new sales appeal to your products with Dow Corning Silicones.

Cross-indexed for handy reference, this



all-new 1958 Guide includes properties and uses for the many new silicone products developed in recent months. A "must" for every design reference file, you can obtain your Free Copy by circling . . . *No. 457*

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

NEW LITERATURE AND TECHNICAL DATA ON SILICONES

Silastic—in mechanical applications—increases life and serviceability of original equipment; reduces maintenance and downtime. A completely new brochure gives properties and cites applications and case histories to help you use this versatile silicone rubber to best advantage in your application. *No. 460*

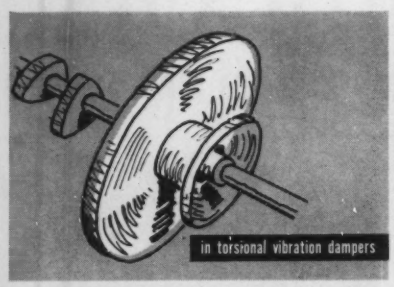
Dow Corning Silicone Lubricants, including oils and greases, are described in a new, illustrated 8-page brochure that gives their properties, lists their applications, and cites factors which contribute to obtaining longer life. *No. 461*

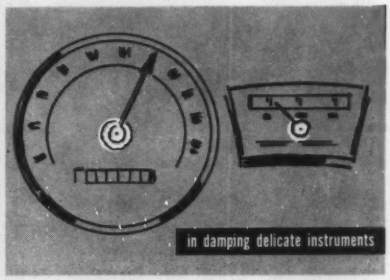
Silicone Materials in Appliance Design, a recent article in ELECTRICAL MANUFACTURING, lists a variety of applications for several different silicones in appliances, describes how silicones have made possible design changes heretofore impractical, and how they extend service life and dependability. *No. 462*

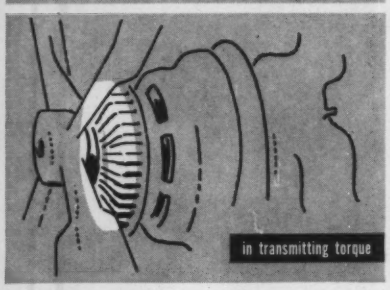
Solventless Silicone Impregnating Resins now commercially available for electrical and electronic equipment, are free-flowing, can be blended, and have good pot life. On curing, these silicone encapsulating resins set to a solid mass having good electrical and physical properties; and retain such properties that a service life of 10 years at 400 F is indicated. *No. 463*

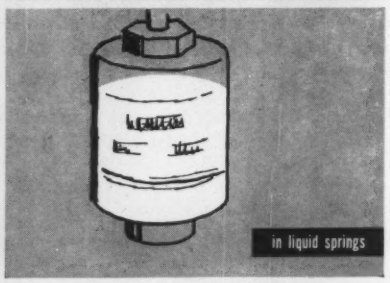
Antifoam B, the lowest priced silicone foam-killer, has greater stability than any other water dilutable silicone defoamer commercially available. Antifoam B will not separate, oil out, settle or precipitate in most applications; retains uniformity and effectiveness even under adverse storage or operating conditions. Ready to use, it requires no diluting or pre-mixing. *No. 464*

"More Muscles for Tomorrow"—A movie in color and sound, gives visual proof of the benefits of silicone electrical insulation. Silicone insulation means increased production, reduced maintenance, freedom from over-motoring, and savings in space and weight. A folder describing the movie and explaining how to arrange for showings is yours on request. *No. 465*





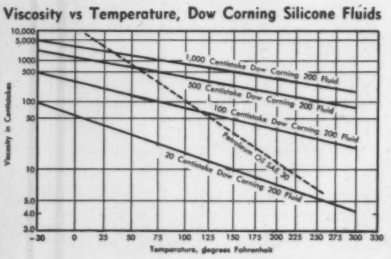




Silicone Fluids Make Automotive Components Perform More Reliably, More Uniformly

Because Dow Corning silicone fluids retain near-constant viscosity over broad temperature spans, they are helping designers hurdle performance barriers set by the limitations of organic fluids, and thereby open the way to many design improvements.

Viscosity vs Temperature, Dow Corning Silicone Fluids



Frequently specified as damping media, coupling fluids and compressible fluids, silicones have proved successful in such designs as torsional vibration dampers, hydraulic couplings, liquid springs, dashpots, delicate gages and instruments.

Future applications in the automotive, aviation and other fields seem limitless when you consider the unique basic properties of silicone fluids: 530 degrees serviceable temperature range, —130 to 400 F; great resistance to oxidation and viscosity breakdown due to shear; high degree of compressibility; low coefficient of expansion.

Available in many viscosities, Dow Corning silicone fluids assure dependable, uniform service under operating conditions that cause organic oils and fluids to deteriorate rapidly. *No. 458*

ADHESIVES FOR TEFLON *(Cont.)*

insulators, and are little affected by extremes of heat, cold and weather. Several manufacturers are now producing silicone adhesive tapes with special backing materials to suit the needs of specific applications. *No. 459*

Dow Corning Corporation, Dept. 6824, Midland, Michigan

Please send me: 456 457 458 459 460 461 462 463 464 465

NAME _____

TITLE _____

COMPANY _____

STREET _____

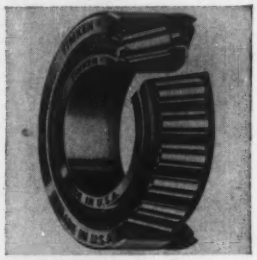
CITY _____ ZONE ___ STATE _____

SILICONE NEWS is published for product design and development engineers by

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS DETROIT LOS ANGELES NEW YORK WASHINGTON, D. C.
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS



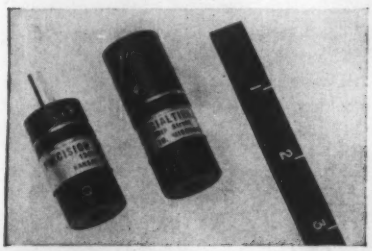
erates in the bearing-housing bore, providing an outside-diameter seal. The other operates against the face of the bearing cup, providing face-type sealing. Seal is supplied pressed onto the bearing cone, and is available on seven different sizes of bearings, from 0.750 to 2.6875 in. **Timken Roller Bearing Co.**, Canton 6, Ohio.

Circle 717 on Page 19

Adjustable Slip Clutches

miniature units transmit from 0 to 5 lb-in. torque

Clutch-couplings are available in two mounting types. They have an OD of ¾ in. and are 2 in. long. Units require no lubrication, and are easily adjusted to transmit



from 0 to 4 lb-in. torque. **Precison Specialties Inc.**, 1342 E. 58th St., Kansas City 10, Mo.

Circle 718 on Page 19

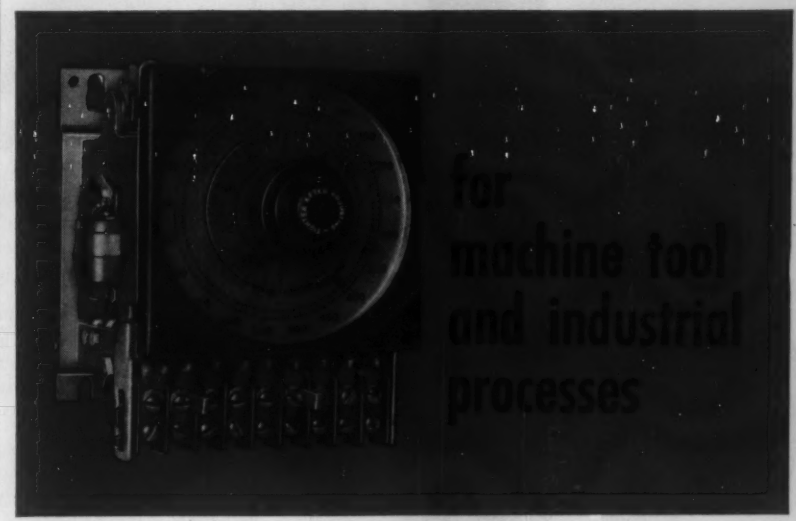
Elapsed-Time Indicator

is miniature unit for airborne applications

Miniature elapsed-time indicator for military airborne applications operates on 28 v dc, is shock-resistant, and is designed to meet requirements of Wright Air Development Center Exhibit WCLSI-4-286222. Unit has plug-in electrical connections for standard crystal socket. It consists of a miniature

(*Please turn to Page 222*)

EAGLE
Microflex reset counter



makes shutdown and feed-down automatic

Convert machine tool and industrial processes from manual to automatic operation — with this Microflex Reset Counter. For example, use it to feed a grinding wheel down after a preset number of operations. Or employ it to shut down a machine at the desired number of operations. This reset counter is ideal for controlling chemical feeding processes by shutting down a pump after the desired number of operations.

The Microflex Reset Counter is actuated by a series of electrical impulses. Models are available with 400 and 1000 count dials. Dial settings easy to make — counting range from 1 to 400 in steps of 1 with 100% accuracy. On 1000 count range, dial settings are in steps of 1 with accuracy of ±1 count. Spring reset in less than ¾ second on full scale setting.

MAIL COUPON TODAY

EAGLE SIGNAL CORPORATION
Industrial Timers Division, Dept. MD-1257
MOLINE, ILLINOIS

Please send free Bulletin 720 containing full data on Microflex Reset Counter.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

Circle 521 on Page 19

New Republic

REPUBLIC NYLOK NUTS offer advantages similar to those of Nylok bolts. They can be assembled from either end with hand or power tools, and lock tight wherever wrenching stops. Holding power is not affected by vibration. "Plastic memory" of nylon pellet gives Nylok nuts excellent adjustment and re-usability characteristics.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Self-Locking Nylok Bolts

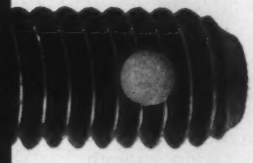
Provide Single-Unit Answer to Vibration, Liquid-Sealing and Adjustment Problems

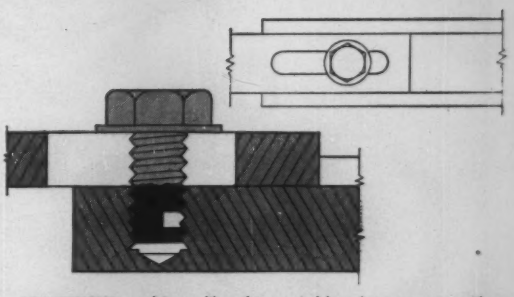
If your bolted assembly must be vibration-proof, liquid-tight or adjustable—Republic Self-Locking Nylok® Bolts are your best fastener selection. You simply align parts to be fastened and turn Nylok bolt into threaded hole. A positive lock is provided, whether or not the unit is seated.

In addition, use of Nylok bolts eliminates lost motion of assembling extra locking devices or expensive wiring. They can be hand wrenched or power driven to minimize fastening time—a tremendous asset in high-volume production runs.

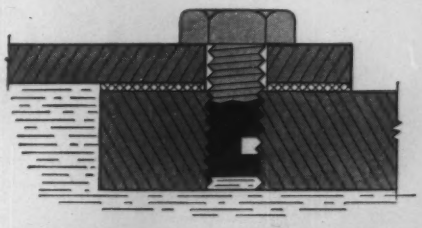
Locking is accomplished by means of a permanent nylon insert in the body of the bolt. This pellet wedges opposite mating threads together to form a vibration-proof lock. There is no damage to threads or seating surfaces, and the insert's resiliency allows fasteners to be adjusted and re-used repeatedly. Further, when properly seated, the nylon insert effectively blocks fluid flow around the helix of the threads. Even relatively soft materials can be locked to a threaded member using Nylok bolts.

When you specify Republic Nylok Bolts you secure the double protection of Nylok locking plus Republic quality, built into each fastener from raw ore to finished product. To find out how you can take full advantage of this ideal combination, contact your Republic representative. Or mail the coupon for further information.

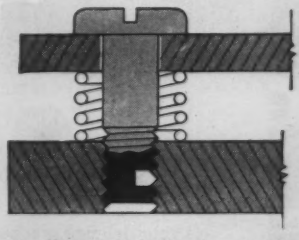




ADJUSTMENT problems like this movable plate are readily solved using Nylok bolts. The nylon pellet allows bolt to be backed off and wrenched tight time after time, without damage to threads, seating surfaces or holding power. Unaffected by age, immune to fungus, pellet won't dry out or shrink.



LIQUID SEALING properties of the Nylok bolt are demonstrated here. Nylon pellet, seeking to regain its original shape, effectively interrupts space between non-loadbearing surfaces of mating threads. Escape of fluid along helical thread path is blocked. Nylon's resistance to moisture and ordinary solvents assures permanence of seal.



VIBRATION has no effect on the locking characteristics of Nylok bolts, even when not wrenched tight as shown here. Secure grip is provided by nylon pellet permanently imbedded in fastener body. Continual pressure of resilient nylon forces tight metal-to-metal lock between mating threads opposite the pellet.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
Dept. C-2704 R
3130 East 45th Street,
Cleveland 27, Ohio

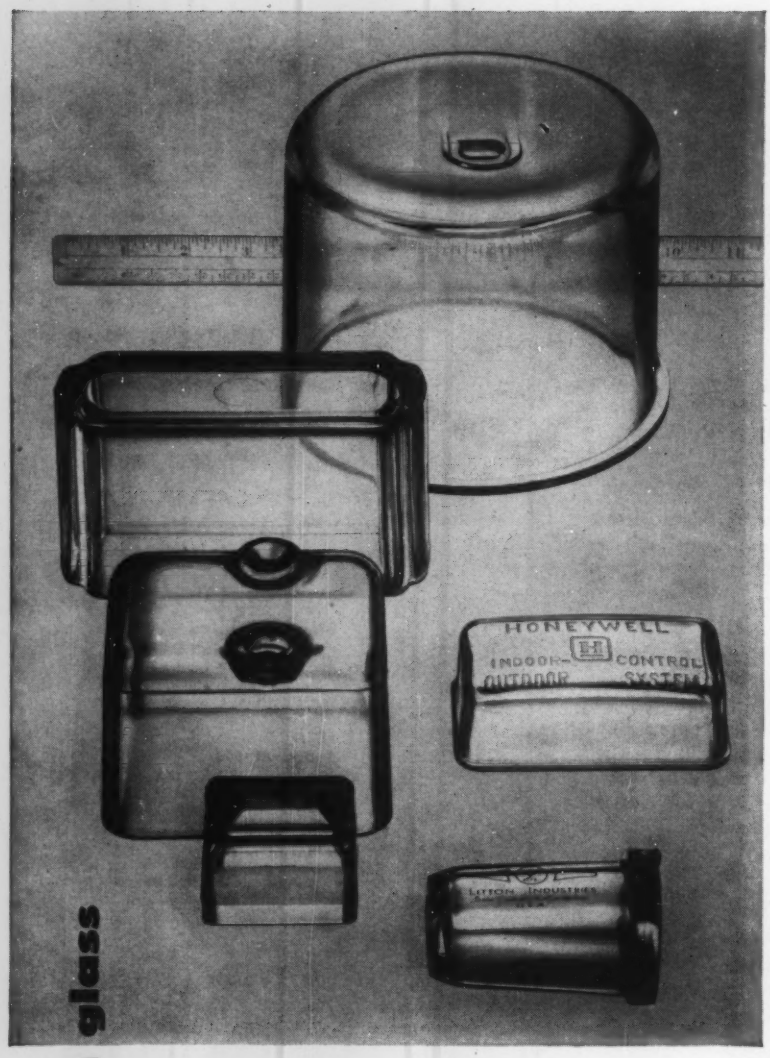
Please send me further information on Republic Nylok Bolts and Nuts.

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____



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Your delicate mechanisms deserve the complete protection and visibility that only glass covers can give. They permit close visual inspection with maximum safety.

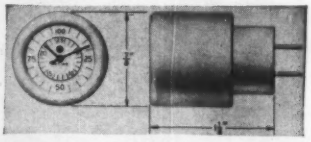
Lancaster has formula and facilities to meet your specific needs in limited as well as mass-produced quantities. Write today for complete details, or send blueprints for quotation to Lancaster Glass Corporation, Lancaster 2, Ohio.

Lancaster
glass and plastics
to brighten your product's future . . .

Circle 523 on Page 19

New Parts

(*Continued from Page 219*)



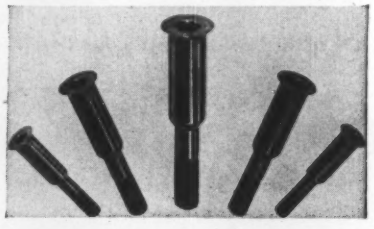
dc motor applying a constant torque to a watch-type gear train actuating the hands, which indicate elapsed time up to 2500 hr. Speed control is obtained by an escapement. **E. Ingraham Co.**, Bristol, Conn.

Circle 719 on Page 19

Alignment Bolts

contain nylon or thermosetting plastic

These alignment bolts realign, through normal installation, any misalignment existing between wing panel skins, access doors and structure, and heavy stainless-steel honeycomb panels and primary structure. Bolts effect extremely high torque values, reduce weight approximately 50 per cent, and provide a rapid method of installation and removal. Bolts are of titanium, type 431 stainless steel, and other materials. Standard internal hex recess produces a large margin over maximum installation



torques. A hole is drilled in the bolt shank, but not deep enough to reduce the section in the necked-down area. Hole, from the bottom of the hex down, is filled with nylon or thermosetting plastic. **Hi-Shear Rivet Tool Co.**, 2600 W. 247th St., Torrance, Calif.

Circle 720 on Page 19

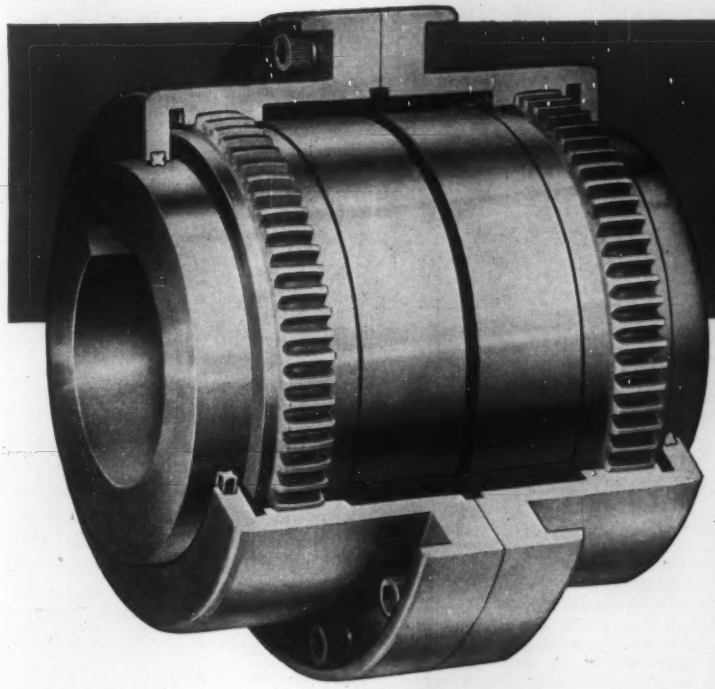
Vacuum Valve

is available in four standard flange combinations

Six-inch, high-vacuum valve, designated VG-106T, is a quick-acting type with unobstructed, straight-

Why LINK-BELT geared flexible couplings can

transmit more hp per coupling dollar



Size for size, they accommodate larger shafts . . . transmit more power than other comparable couplings

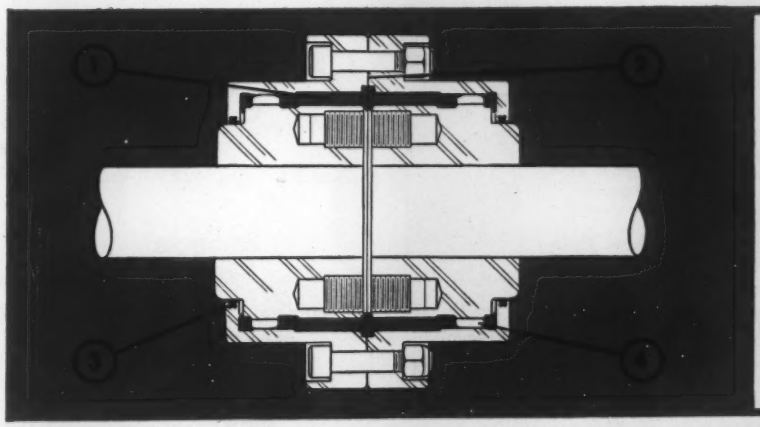
LINK-BELT geared flexible couplings offer an ideal combination of compactness, performance and low cost. They're designed for high load capacity, yet cost less because they are smaller.

Hardened steel socket head flange bolts —ground for close fit—are the key to compactness. They permit a smaller flange. Thus, more of the coupling diameter is devoted to the gear and a larger hub which can be bored to accommodate larger shafts.

In a great variety of coupling applications—including those where shock, vibration, reversing loads and misalignment are encountered—these couplings can be used effectively to assure long life and minimum maintenance. Popular sizes are available with finished bores, packaged and ready for installation. For complete details, contact your nearby Link-Belt office. Or write for your copy of Folder 2775.

LINK-BELT

GEARED FLEXIBLE COUPLINGS



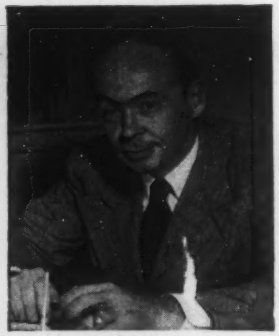
2-piece housing design assures efficient sealing and lubrication

1. In operation, the lubricant centrifuges to the working gear surfaces at the perimeter of inside cavity.
2. Fiber gasket fits tightly between flanges. Lubricant can't escape.
3. Hub seal is smaller in diameter than gear teeth and running level of lubricant. No leakage is possible—dirt and water stay out.
4. Mating gear teeth are constantly lubricated, preventing wear and providing long, trouble-free operation.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,484-A

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS,** *President*
New Hampshire Ball Bearings, Inc.



DYNAMIC AND STATIC LOAD RATINGS

Load ratings of MICRO bearings are based on standards established by the Anti-Friction Bearing Manufacturers Association and are the result of extensive tests.

The "life" of an individual bearing is defined as the number of revolutions the bearing makes before the first evidence of fatigue develops. Fatigue, in turn, is a function of bearing load and although other factors, such as contamination and high temperature, affect the life of a bearing, it is assumed that clean bearings running at normal temperatures are being considered.

It is not possible to predict the life of any individual bearing. The problem, therefore, is best approached by a consideration of empirically derived dispersion curves which provide a means of determining bearing life on a probability basis. That is, they permit the average life of a given group of bearings to be accurately specified.

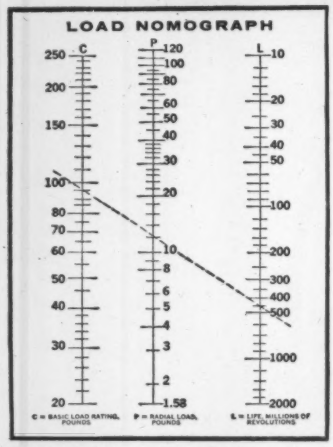
For purposes of standardization, the "rating life" of a group of apparently identical ball bearings is defined as the number of revolutions that 90% of the group will complete or exceed before the first evidence of fatigue develops. This figure is approximately one-fifth of the average life.

If two groups of similar bearings are run under different loads F_1 and F_2 within normal operating range of loading and rpm, their lives L_1 and L_2 are inversely proportional to the cubes of the loads, i.e., The BASIC LOAD RATING C is that radial load which a group of apparently identical bearings can endure for a rating life of one million revolutions, with stationary load and rotating inner ring. Within normal operating ranges, rating life for any load is a constant number of revolutions, so the following relationship, a restatement of the inverse cube proportion, may be used to compute rating life when basic load rating and applied radial load are known:

$$L = \left(\frac{C}{P}\right)^3$$

L=rating life in millions of revolutions
where, C=basic load rating in pounds
P=applied radial load in pounds

The nomograph illustrated permits the quick evaluation of any one of the three quantities when the other two are known. For example, if the C rating of a given bearing is 95 pounds, and the bearing is loaded radially with



12 pounds, P, a straight edge crossing these two values in their respective columns shows that the bearing could be expected to have a life, L, of 450 million revolutions.

"EQUIVALENT LOAD"

Bearings whose loads are primarily radial are usually also subjected to axial forces. When the axial component of the load is greater than a negligible value, this combined radial and thrust load may be expressed in terms of a simple radial load in order that the basic load rating C may be calculated. This simple radial load is known as the "equivalent load", which is that constant stationary radial load which, if applied to a rotating inner ring, would give the same life as that which the bearing will attain under the actual conditions of load and rotation.

A formula for determining "equivalent load" and a more comprehensive discussion of static and dynamic loads is found in our design handbook.

DESIGN HANDBOOK OFFERED *FREE*

You'll find this new, 70-page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.

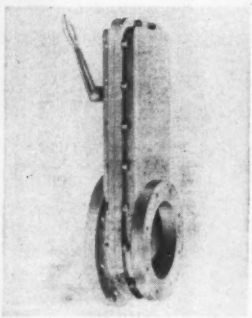
Write to: New Hampshire Ball Bearings, Inc., Peterborough 1, N.H.

Typical cut-away views of instrument-type retainer ball bearings.

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE
District Offices: Pasadena, Calif.; Park Ridge, Ill.; and Great Neck, N. Y.

New Parts

through opening. Slide action is actuated by a half-circle handle turn. There is no valve-disc contact until closed, eliminating scuffing and wear. Closing action is a ball-and-socket principle with no pins to shear. Load is on the socket. Valve is available with manual or remote control, in four standard flange combinations. The thin-design valve has applications



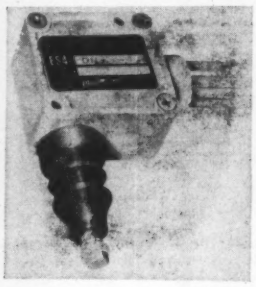
in vacuum systems for atomic power, and in the metallurgical, electronic, chemical, instrument, ordnance, plastics, missile, microwave, petroleum, and other processing industries. **Vacuum Research Co.,** 420 Market St., San Francisco 11, Calif.

Circle 721 on Page 19

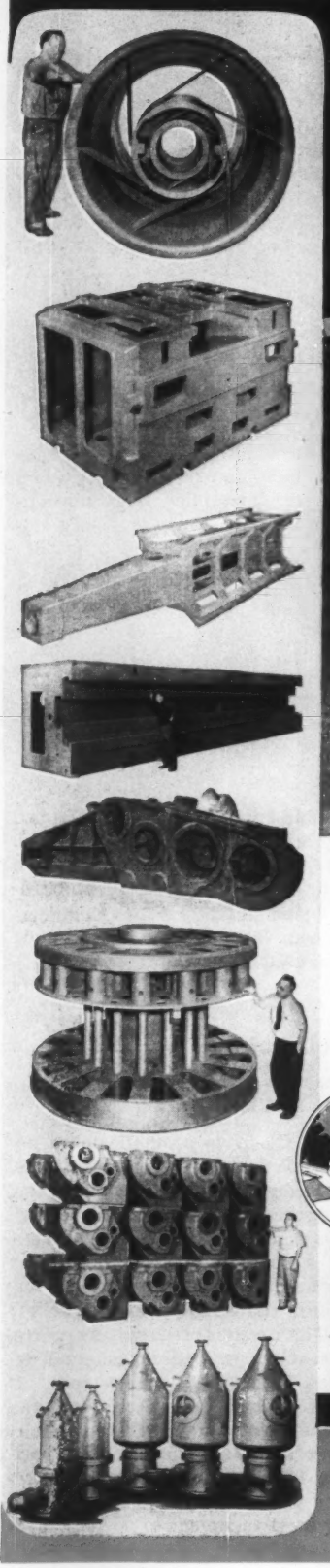
Snap-Action Switch

has one-way action on two poles

ES4-DM3 die-cast switch provides simultaneous, one-way action on two poles, resulting in an electrical impulse on the inward stroke, but not on the return to normal position. Snap action of the four-circuit switch mechanism is totally independent of the speed of the plunger movement. The double-pole, double-throw switch is housed in an aluminum die-cast case with splashproof neoprene boot



Steel-Weld FABRICATION



Use WELDED STEEL for Greater Strength with Less Weight!

The weldment shown above is the frame for a sixteen cylinder Diesel Engine designed for a potential of 5000 H.P. This precision piece, and those illustrated at the left are typical of thousands of Steel-Weld Fabricated parts and assemblies produced by Mahon each year for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. If you are not now taking full advantage of the economies offered by welded steel components in your product, you should give the matter serious thought. In the design of almost any type of heavy machinery there are parts and sub-assemblies that can be produced more economically, more satisfactorily, and in less time, in welded steel. In weldments you get greater strength with less weight—plus the additional advantages of greater rigidity and 100% predictability. When you consider weldments, you will want to discuss your requirements with Mahon engineers, because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with complete facilities for design engineering, fabricating, machining and assembling . . . a source where design skill is backed up by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

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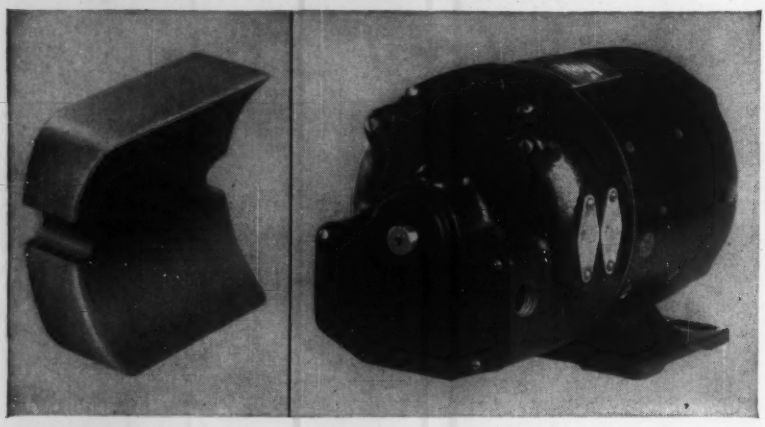
Circle 526 on Page 19

New trends and developments in designing electrical products . . .



General Electric permanent magnet outperforms wire-wound field in D-C tachometer generator

Improved Alnico 6 magnet increases reliability and accuracy over wide ambient temperature range.

Instruments can determine rotational speeds from 100 to 5000 rpm with an error of less than .05% — despite ambient temperatures of 20° to 50° C. Problem is that these instruments are only as accurate as the tachometer generators that supply their power.

Conventional generators use copper windings. This means they are dependent on external — and often varying — power sources. They are adversely affected by wide temperature changes. And, they are costly to repair when windings burn out.

The 46-frame D-C generator, above, gets around these difficulties by using a G-E Alnico 6 permanent magnet. Here's why:

1. The G-E Alnico magnet does not depend on outside excitation.
2. It supplies reliably constant power.
3. Exposure to varying ambient temperatures does not affect the magnet's power or dependability.
4. External regulating equipment —needed with wire-wound fields —is eliminated by the use of Alnico magnets.
5. Unlike copper windings, permanent magnets never wear out.

These advantages, in themselves, were enough to make the magnet-powered generator a success.

However, with conventional Alnico 6, plastic-steel was needed between the "as-cast" surfaces of the magnet and the machined parts of the generator to cut eddy current losses, and to shield the flux. This added to the time and cost of producing the generator; made it almost impossible to disassemble for normal servicing and maintenance.

So G-E magnet engineers increased the coercive force of the Alnico 6 magnet by about 7%. The need for the plastic-steel "mud" was eliminated . . . and so were the difficulties of assembly and disassembly.

This generator is just one of the many applications where G-E magnets can outperform wire-wound fields for accuracy and reliability. And the work of G-E Magnet Engineers in improving Alnico 6 is just one of the many services they offer to designers and manufacturers of electrical products.

For more information about G-E magnet engineering services, or for your copy of the new G-E Magnet Design Manual, write: *Magnetic Materials Section of General Electric Company, 7814 N. Neff St., Edmore, Michigan.*

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GENERAL ELECTRIC

New Parts

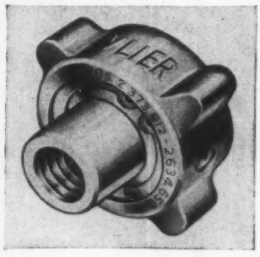
to protect switching mechanism. Switch is suitable for pulsing electrical control on both pneumatic and hydraulic valves and other similar installations requiring momentary one-way electrical impulses. It is rated 15 amp 125/250 v ac, 30 v dc. **Electro Snap Switch & Mfg. Co.**, 4218 W. Lake St., Chicago 24, Ill.

Circle 722 on Page 19

Adjustable Torque Handle

controls clamping pressure from 15 to 200 lb

This adjustable torque handle controls clamping pressure on jigs and fixtures, assemblies, and machinery. End pressure is easily ad-



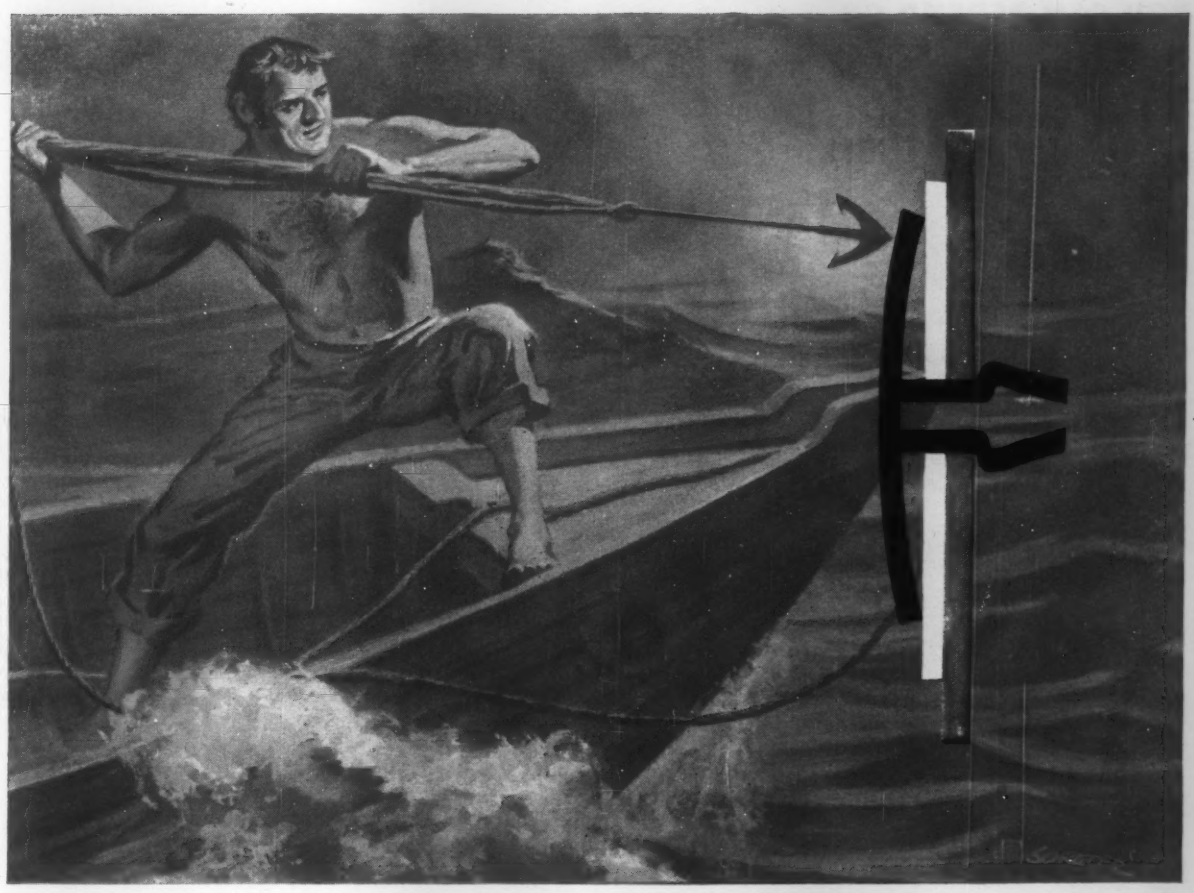
justable from 15 to 200 lb. Tapped hole is available in 5/16-18, 3/8-16, and 1/2-13 sizes. Aluminum handle is die-cast with an integral hardened-steel insert. **Vlier Engineering Inc.**, 8900 Santa Monica Blvd., Los Angeles 46, Calif.

Circle 723 on Page 19

Small Clutch

handles engines up to 4 hp

Model CL-57 is a small clutch developed for garden power tools, transmissions, marine applications, generators, pumps, and shop equipment. Weighing 2 lb and occupying a space of 2½ in., it handles engines up to 4 hp. Clutch operates on the torsion-spring principle and has only three moving parts. It requires no end thrust, and delivers high torque at low rpm. It rotates in either direction, and torque arm can be located in any one of three positions. Each position is separated from the alternate positions by 120 deg, providing for attachment to power source at any point around the shaft.



HARPOON-ACTION FASTENER
simplifies front mounting

Thrust this Tinnerman Dart-Type SPEED CLIP® through the front of a panel. Spring-steel fingers compress, then expand to lock tight, never to loosen until you pull the clip out.

This time-saving SPEED CLIP feature can be combined with other Tinnerman fastening principles and almost any spring-steel shape. Result—multi-purpose, cost-cutting fasteners that solve a variety of fastening problems. You eliminate screws, nuts, lockwashers, secondary fastening methods. You reduce parts handling and achieve a faster, smoother assembly-line flow.

Your Tinnerman representative can show you these and many other SPEED NUT® Brand Fasteners that can help take assembly costs out of your products. Call him today. Or write to . . .

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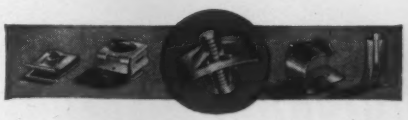
Speed Nuts®



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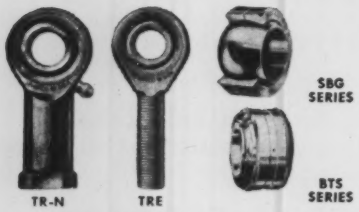

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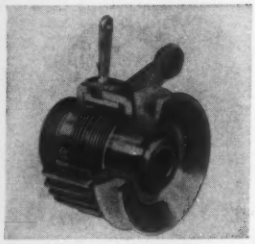
Circle 529 on Page 19

New Parts



Both 5/8 and 3/4-in. keyed shafts are available. **Tru-Torque Sales Co. Inc.,** 11275 Massachusetts Ave., West Los Angeles 25, Calif.

Circle 724 on Page 19

Silica Glass Tubing

in bore diameters from 1/8 to 3 in.

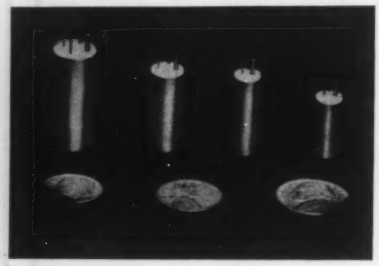
Vycor 96 per cent silica glass tubing has ID tolerances up to ±0.0005 in. It is available with precision bores in diameters from 1/8 to 3 in. Maximum length of tubing is 36 in. Low thermal expansion, excellent dielectric characteristics, and chemical stability give the tubing excellent properties for high-standard electronic equipment. It withstands extreme temperature differentials (to 900 C) and is unaffected by close contact with reactive or corrosive materials over a long period of time. Other uses include measuring devices in high-temperature work, enclosures for high-frequency, high-temperature transmitters and receivers, and precision resistors. **Corning Glass Works,** Corning, N. Y.

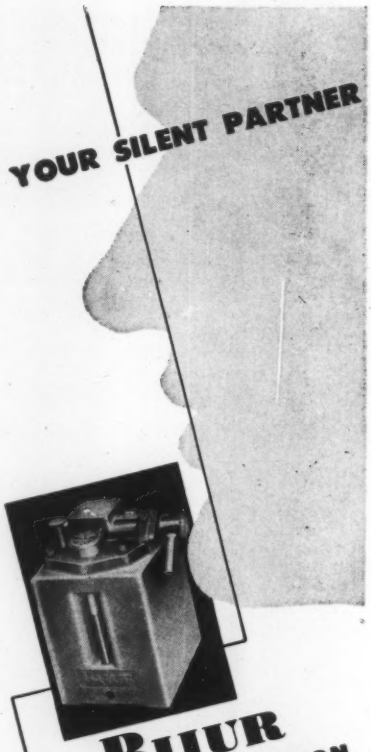
Circle 725 on Page 19

Electrolytic Capacitors

are miniature, upright units

Miniature, upright aluminum electrolytic capacitors have ratings from 1/2 to 680 mf, and voltages





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AUTOMATIC LUBRICATION

HELPS YOU
• effect real savings in your own plant
• design savings into the equipment you make

Hand oiling is costly! It wastes time and money . . . steals valuable production hours . . . means extra down-time, fire risk, repair bills, replacement parts and causes product damage from excess lubricant.

But there's a way to end all this waste and worry. A Bijur Automatic Lubrication System never forgets a bearing . . . bearings never are thirsty for oil, never flooded. Lubrication is continuous, exactly right. All the hazards of hand oiling are banished—*automatically!*

Bijur Systems are custom-engineered for machinery used by practically all industries. Every bearing receives a clean supply of oil at the right time . . . automatically and correctly metered to suit its individual needs . . . while the machine is running! Whether for new equipment you *buy*, or machines you *build*, insist on Bijur. It's better—*by design!*

P-5

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Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

Circle 530 on Page 19

Seeburg designers choose P-K screws

to match the fastener to the job!

Joseph Kamys, engineer, J. P. Seeburg Corporation, Chicago, manufacturers of coin operated phonographs says, "Seeburg standards demand attention to every detail—quality workmanship and materials throughout. With Parker-Kalon screws, we can match the fastener to the specific application—be sure of dependable results."

Attachment of metal base molding and kickplate to a Seeburg cabinet, in a metal-to-wood application. "Rather than use ordinary wood screws, we power-drive P-K Self-tapping Type-A," says Mr. Kamys. "Holding power is far better, there's less chance of wood splitting, and fewer rejects at inspection."

Here, metal rims of two high-frequency speakers are fastened to a formed, one-piece, plastic housing. "In this metal-to-plastic application we have not only the problem of possible plastic breakage, but the fastener used must be highly resistant to vibration. We find P-K thread-forming Type-Z screws highly satisfactory."

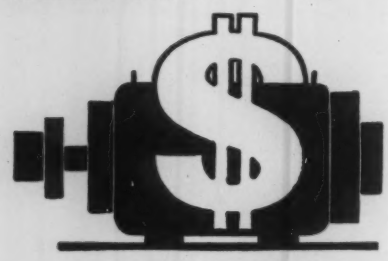
If you are designing a new product or new model, it will pay you to talk with a Parker-Kalon Field Engineer. He can help in the selection of proper fasteners, can often suggest ways to speed production—cut costs. You can contact him through your local Parker-Kalon Industrial Supply Distributor.

***PARKER-KALON DIVISION,** General American Transportation Corporation, Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws.*

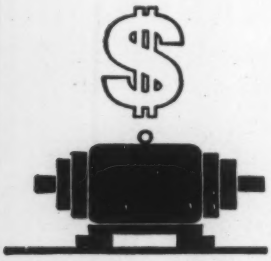
Sold Everywhere Through Leading Industrial Distributors. Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois, Los Angeles, Calif.

PARKER-KALON®
fasteners

When electrically driven equipment calls for...

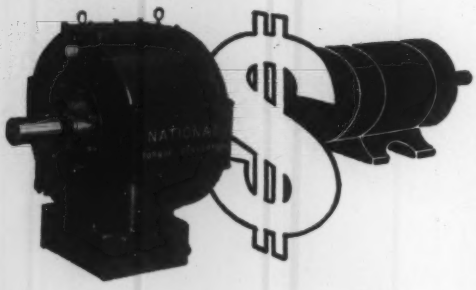


a special, costlier motor to start things



but only a low-cost motor to run them

Why not try this...



A National Torque Converter to give high starting torque | with your cost-saving motor to keep things moving

National Torque Converters give you "big motor" torque from small motor investment

Like a car in heavy traffic, the work-cycle of a lot of heavy, electrically-driven equipment is stop-and-go, stop-and-go.

If the motor is selected to take care of *running* requirements, it won't have the starting torque needed to pick up heavy loading fast. If the motor is selected for *starting* requirements, it is likely to cost considerably more—both to buy and to run.

The best answer is to install the more economical motor—and let it drive through a National Torque Converter. The converter will multiply the motor's torque for picking up the loads . . . ease the shocks and stresses of operation . . . bring economy in first cost and day-to-day service. National Torque Converters are available in a range of capacities from 100 to 1000 HP. For detailed technical information, just write:

THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

Two Gateway Center, Pittsburgh 22, Pa.

Pace-setters in the progress of industrial power transmission

New Parts

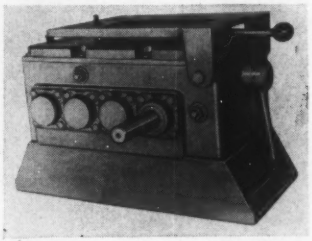
from 4 to 150 v. Each capacitor may contain up to three individual electrode elements. Operating temperature range is −20 to 85 C. Can heights range from ½ to 1¼ in., and diameters from ¼ to ⅝ in. Connector pins are positioned in a square, and alignment is accurately maintained to permit automatic insertion in printed-circuit boards. Case is sealed with epoxy-casting resin. **Magnavox Co.**, Bueter Rd., Ft. Wayne 4, Ind.

Circle 726 on Page 19

Multispeed Transmissions

have capacities from 1 to 60 hp

Models 240 and 540 transmissions have selective gears in four, six, and nine ranges of speed. Standard high-to-low output ratios vary from 4.7:1 to 8:1, with maximum



12.4:1 step-down. Step-up ratio of 1:8 is possible in certain applications. Standard units have capacities from 1 to 60 hp. Applications include use on road machinery, oil or water-pumping rigs, conveyors, testing machines, textile frames, rolling mills, wire-drawing spindles, oil core-drills, and paper-making rolls. **Turner Uni-Drive**, 3484 Terrace St., Kansas City 8, Mo.

Circle 727 on Page 19

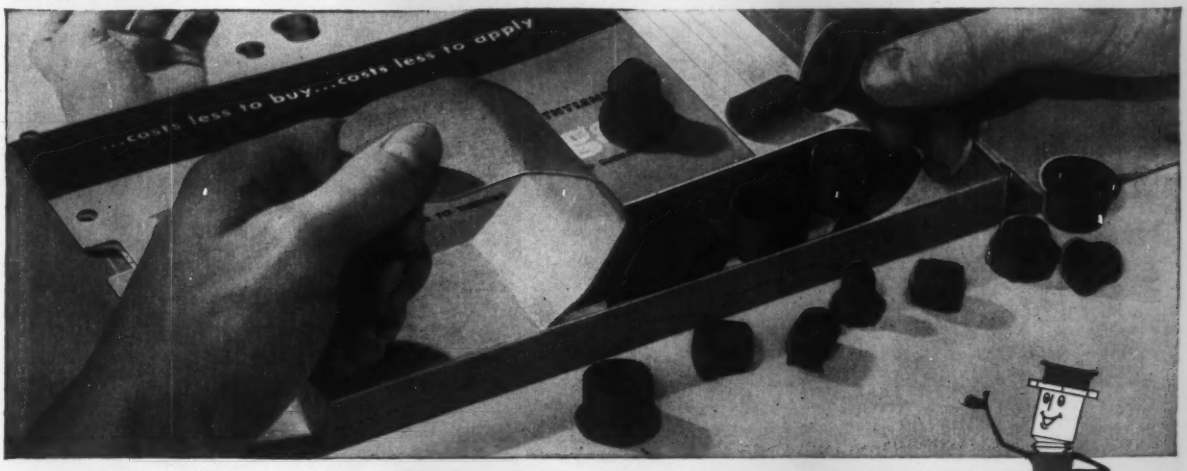
Nonreset Counters

have nylon ratchet components

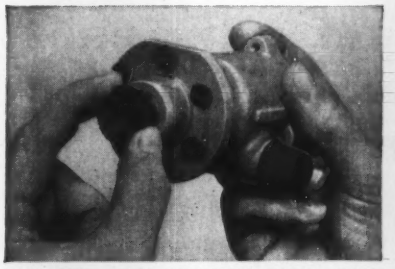
Small, cylindrical-case nonreset counters have case diameter of 0.790 in. with mounting flanges at the figure window or at the bottom (shown). They are available with from three to six figures, 0.163 in. high, in white on a black background. Drive shaft is ⅛ in. in diam and projects from left or right-hand end of case. Revolutions can be counted at a maximum

Circle 532 on Page 19

which **CaPlug** will protect <u>your</u> product best?

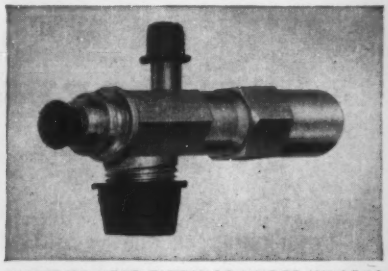


write for this free sample kit and see!



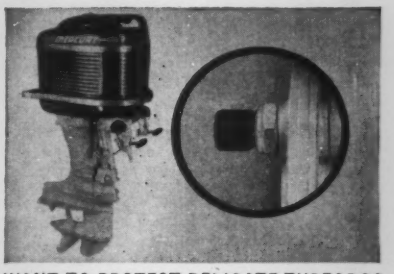
WANT TO SEAL OPENINGS IN A JIFFY?

Tapered (non-threaded) CaPlugs can be used as caps or plugs, inside and outside of threaded or plain fixtures. Just push them on . . . or push them in. Costing less to buy, these versatile closures cost less to apply. Time studies show that tapered CaPlugs save up to 500% in labor costs.



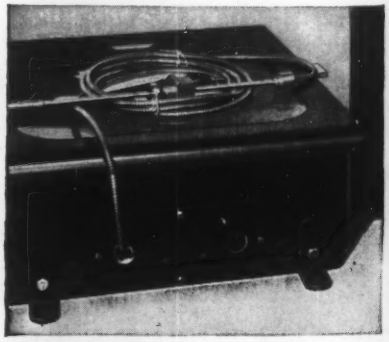
WANT TO KEEP FITTINGS UNDER WRAPS?

See how CaPlugs seal out dust and protect fittings of this refrigeration valve during shipment. Says Automatic Machine Products Sales Co., "It is important that the valve be free from contamination, since a large percentage of refrigeration systems are hermetically sealed and guaranteed for five years. CaPlugs are easy to install and afford the protection we desire."



WANT TO PROTECT DELICATE THREADS?

Kiekhaefer Corp. guards the threads on the "Ride Guide" steering controls of its Mercury outboard motor with *threaded style* CaPlugs. Here's long-lasting protection . . . the customer can reuse the CaPlugs when storing his motor. Made of tough, flexible Polyethylene, CaPlugs are especially kind to threads and polished surfaces — will not collapse, chip, break or shred.



WANT TO ADD SALES APPEAL?

Colorful CaPlugs spruce up your product and reflect the care you have taken to keep delicate systems free of dirt, moisture or foreign matter. This Bristol air control instrument is a good example. Says The Bristol Company, "They are sturdy enough so that they are not accidentally dislodged, but are still easily removable."

CAPLUGS FIT PRACTICALLY ANY CLOSURE NEED YOU CAN NAME.

Ten standardized designs (both threaded and non-threaded) are stocked in over 500 sizes to give you low-cost protection for tubing, fittings, valves, hydraulic components and machined parts of every description. Your immediate requirements can be met promptly with "off-the-shelf" deliveries from a multi-million inventory.

MAIL THIS COUPON FOR FREE CAPLUG SAMPLE KIT WITH DESCRIPTIVE LITERATURE AND PRICES

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC., 2201 Elmwood Ave., Buffalo 23, N.Y.

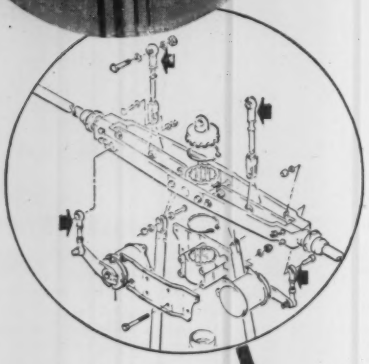
RUSH a free CaPlug sample kit, literature and prices to us, without obligation.

NAME _____ TITLE _____

FIRM _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____



THE NEW "BELL RANGER" HELICOPTER USES HEIM UNIBAL ROD ENDS

Model 47-J is the latest helicopter to be introduced to the commercial market by Bell Helicopter Corp., and has been named the Bell Ranger. It is a four-place, executive type machine with a deluxe interior or a series of quick-change cabin arrangements for cargo, litter, and internal hoist configurations.

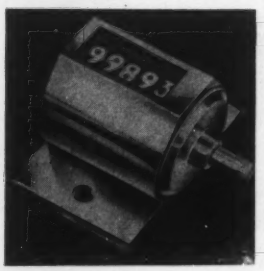
HEIM Unibal Rod Ends were chosen for the linkages in the carburetor heat and mixture control installations, and in the main rotor stabilizer bar assembly. The rods link hydraulic dampers to the bar, which provides exceptional stability to the flight characteristics of Bell helicopters, acting like a gyroscope and, through mixing levers, keeps the rotor plane of rotation in its pre-established flight path.

THE HEIM *Unibal* is the spherical bearing which corrects misalignment in every direction because of the universal movement of the ball — Reduces friction and lost motion in linkages — Eliminates the effects of vibration — Lowers assembly costs because of its quick and easy installation — Carries heavier loads.

Perhaps Heim can help solve — or simplify — your linkage problems. Feel free to write. Be sure each engineering and purchasing department has a Heim catalog.

THE HEIM COMPANY / Fairfield, Connecticut

Circle 534 on Page 19



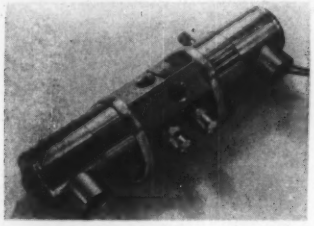
of 1000 per min, or count can be recorded at 1000 per min with shaft input of 100 rpm. Two types of ratchet action are available. Ratchet components are nylon for self-lubrication, low inertia, and positive action at high speed. All counters return to zero after maximum count has been reached. Units are available from **Technicraft Co.**, 6221 Ridge Ave., Philadelphia 28, Pa.

Circle 728 on Page 19

Piloted Air Valves

for use with air or other noncorrosive gas

Solenoid valve-piloted air valves incorporate twist-type manual actuators which permit control and operation of the air cylinder during set-up and try-out of the control system. The single and double-solenoid valves are full pressure piloted and are available in ⅛ to ½-in. sizes for use with air or other noncorrosive gas. **Beckett-Harcum Co.**, Wilmington, Ohio.



Circle 729 on Page 19

Conductivity Cell

determines impurities in free-flowing liquids

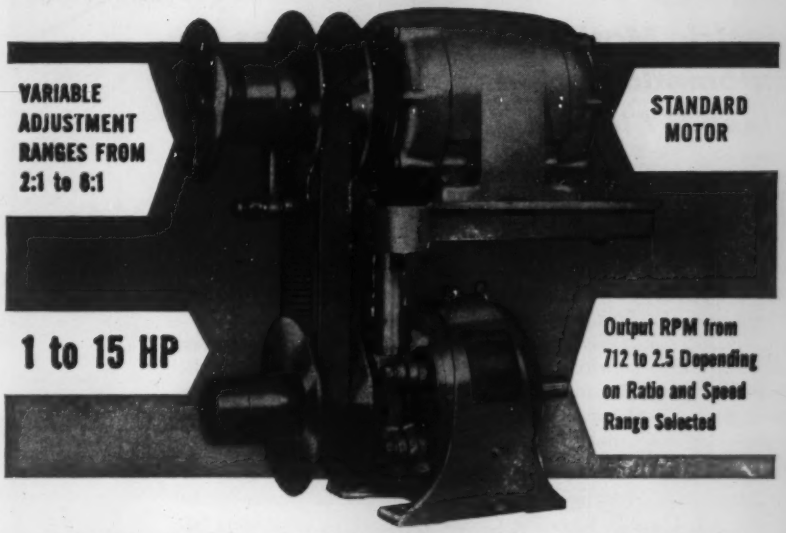
New conductivity cell, designed to be mounted directly on the main process line of free-flowing liquids, consists of a hollow glass cylinder containing two electrodes

(*Please turn to Page* 236)

NEW FROM FOOTE BROS.

Vari-Mount

VARIABLE SPEED MOTORIZED DRIVE



VARI-MOUNT—the new Variable Speed Motorized Drive offers infinitely variable speed selection, greater flexibility of operation, wide adaptability, easier maintenance and the sound design you expect from Foote Bros.

With a Vari-Mount, you can use your own motor—old or new NEMA Standard—or, the unit can be supplied with any standard motor of your choice. The Vari-Mount Reducer incorporates Duti-Rated Lifetime Gearing with file-hard tooth surfaces and tough, ductile cores for maximum life and efficiency.

Positive handwheel control of the adjustable pulley permits pin-point accuracy in speed selection over the entire range. Vari-Mount Units may be equipped with Remote or Automatic speed selection devices if required.

Spring loaded, self-centering Variable Pulley and close-coupled in line design insures permanent belt alignment, smoother performance, and minimum overhung load on motor bearing. No thrust load is imposed on motor bearings at any speed or during speed changes.

Quick belt changes made possible by the wide-open design of the Vari-Mount, together with easily accessible lubrication fittings make maintenance an easy matter.

3 TYPES 7 standard mounting positions

Want complete details?...Write for Vari-Mount Catalog today

this trademark stands for the finest industrial gearing made

T. M. REG. U. S. PAT. OFF.

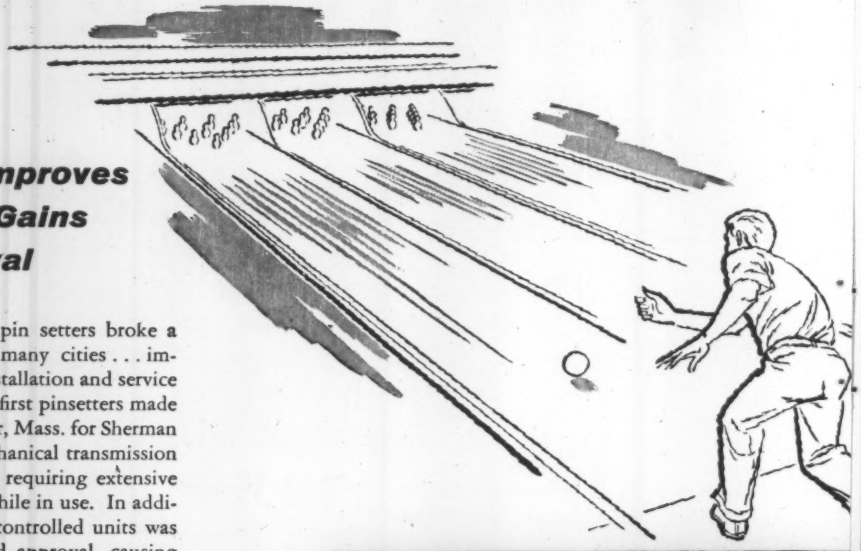
FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 SOUTH WESTERN BOULEVARD · CHICAGO 9, ILLINOIS

Circle 535 on Page 19

WARNER ELECTRIC CLUTCHES EASILY CONTROL COMPLEX MOTIONS OF AUTOMATIC PINSETTER

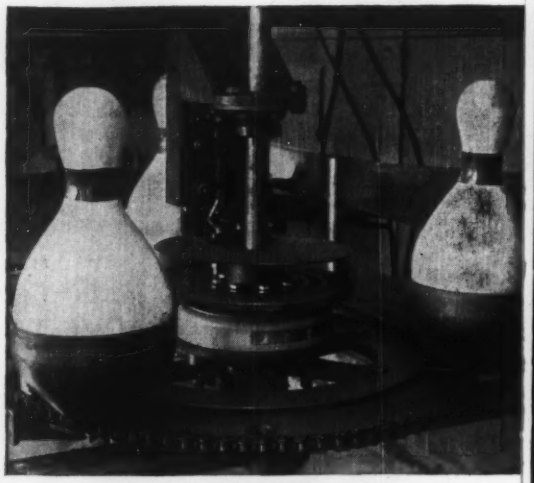


Electric Motion Control Improves Automatic Performance, Gains Class II Electrical Approval

Here's how a manufacturer of automatic duckpin setters broke a bottleneck preventing use of the machine in many cities . . . improved machine performance . . . and reduced installation and service costs with Warner Electric Motion Control. The first pinsetters made by Crompton & Knowles Loom Works, Worcester, Mass. for Sherman Enterprises, Worcester, were equipped with mechanical transmission and braking controls . . . complex in operation, requiring extensive adjustment at installation and frequent service while in use. In addition, the voltage demand of the mechanically controlled units was so high that Underwriters' Laboratories refused approval, causing many cities to withhold operating licenses.

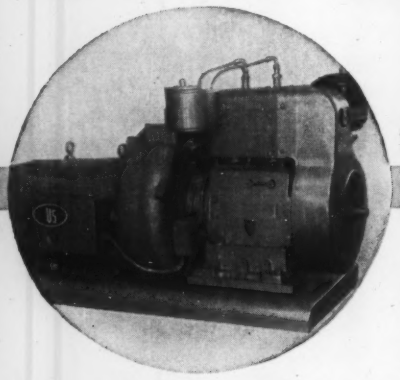
Use of Warner Electric Clutches was the solution to Crompton & Knowles' problems. The low operating voltage of the Warner system gained UL Class II Signaling Circuit approval . . . installation became greatly simplified . . . the timing sequence and operation more reliable and precise . . . and field service greatly reduced.

Warner Electric Motion Control systems offer you pushbutton, centralized control integrated with your machine's electrical circuit . . . expand the uses of all types of automatic control devices . . . give you the exact operating characteristics needed to do every job better, at lower over-all cost. You get faster, more precise starts and stops . . . and you benefit from simplified design and installation. Use the coupon on the next page to obtain the complete story on Warner Electric Motion Control.

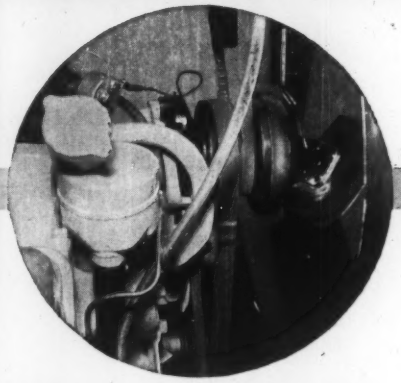


EASILY SOLVES POWER PROBLEMS LIKE THESE

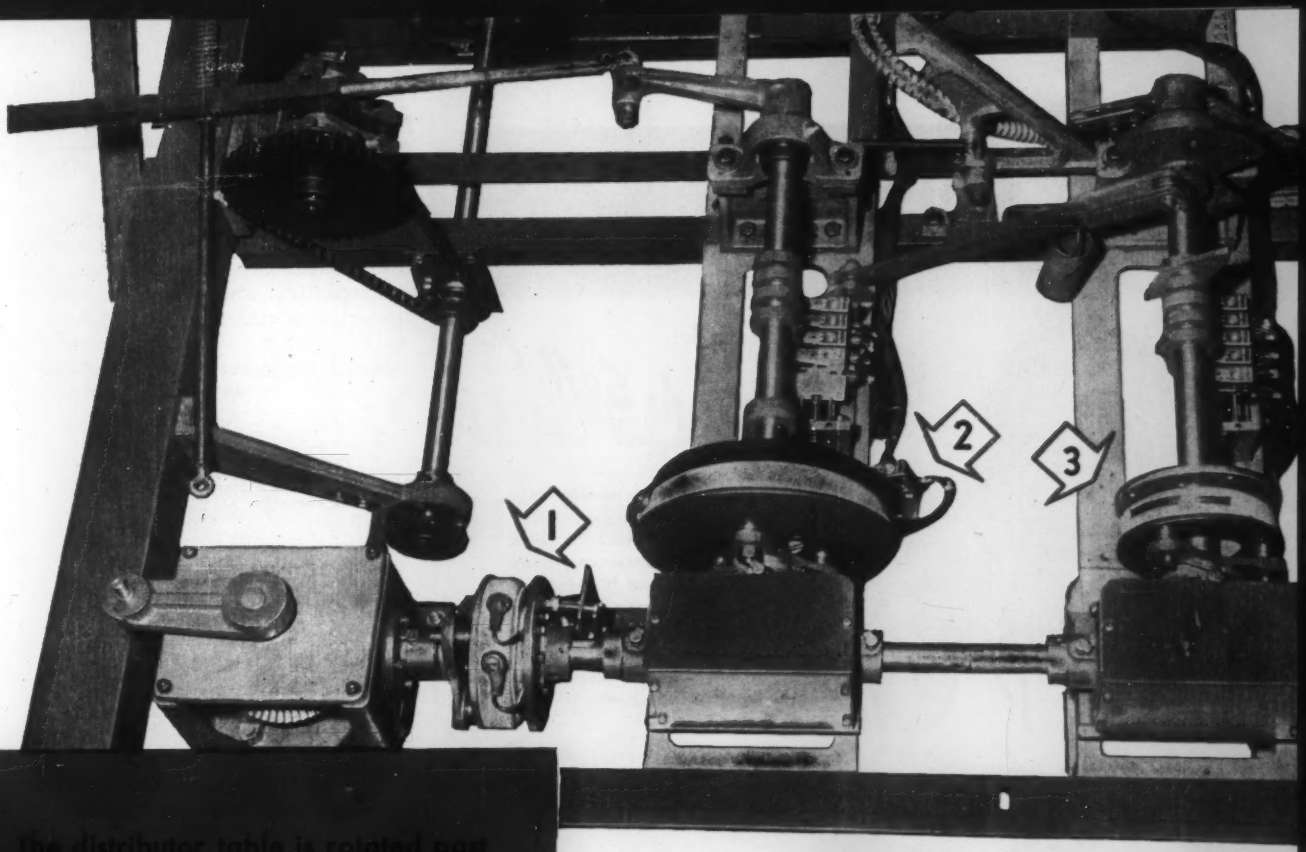
Automobile Air Conditioning—Automatic control provided by Warner Clutch has stationary magnetic field mounted on compressor seal plate and rotor keyed to compressor shaft with armature-pulley mounted on rotor hub. Pulley driven by engine crankshaft. Clutch field is energized by thermal control coupling armature and pulley, driving compressor. Control releases clutch when proper temperature is reached.



Stand-By Power Plant—Electric Clutch is mounted on shaft between heavy flywheel of continuously running electric motor alternator and gas engine. Power failure or drop disengages motor from prime supply and energizes field, engaging flywheel with engine. Inertia of wheel starts engine, preventing power interruption or variance. Sequence occurs instantly with only 4 or 5 volt lag for a few seconds on 110 volt lines.



Heavy Truck Fan Clutch—Clutch armature and fan are mounted on stationary shaft adjacent to rotor and pulley assembly. Integral rotor and pulley turn continuously. Field is mounted on water pump. Thermal switch in water cooling system energizes field, attracting armature and driving fan. Intermittent operation makes more horsepower available to the vehicle and provides faster warmups in cold weather.

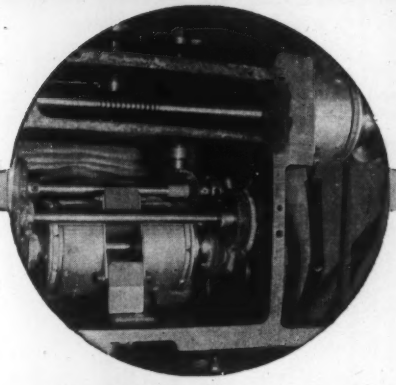


The distributor table is rotated past a chain pin conveyor until all ten cups are filled—pins are then held until needed by pin table. Warner Electric Clutch provides quick, precise control of full sequence.

1 When bowler steps on switch at the head of the alley, this Warner Clutch and timer arrangement activates the sweep arm to clear "dead" pins from the alley.

2 The pin table which places the pins in position or lifts them while sweep arm cleans alley is precisely controlled by this Warner Electric Clutch arrangement.

3 Pins lifted from the alley pit are received by the distributor table and delivered as required to the pin table. This Warner Electric Clutch actuates the delivery table sequence.



Bobbin Resistor Winder—Unusual use of Warner Brake on wire guide carriage. Brake is energized continuously to hold worm gear stationary as it traverses machine's screw. When brake is de-energized at end of winding operation, worm gear is released, returning carriage to start. Second brake on spindle stops winding at exact preset turn. Two Warner Clutches control winding and reversing traverse.

Circle 536 on Page 19

Beat competition with

ELECTRIC BRAKES AND CLUTCHES

Warner Electric Brake & Clutch Co.
Dept. MD, Beloit, Wisconsin

Please send me copy of your new Condensed Catalog No. 6212.

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

IT PAYS TO HAVE HUBBELL GOOD CONNECTIONS

PRECISION MACHINE SCREWS

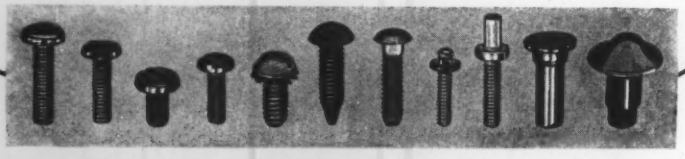
Make it Easier to Sell!

. . . because with high quality fasteners your product earns a reputation for better performance and longer life service. Experience proves that the initial higher cost of quality components is offset time and time again by such things as operating efficiency, good appearance, better accuracy, etc.

Better Steel means Better Quality

The carbon steel heading wire used in the production of standard Hubbell Screws is A.I.S.I. Grade C-1010. Special application screws with higher strength or torque value requirements are produced from A.I.S.I. Grades C-1013, C-1020 and C-1035. Those subjected to drilling or subsequent tapping operations are produced from A.I.S.I. Grades C-1108 or C-1110.

All carbon steel wire used in the production of Hubbell screws, regardless of grade, is annealed in process material to specified tensile strength and is drawn to restricted size tolerance to insure the high Hubbell standards of quality and size in the finished screws.



Prices and delivery on request. Simply send blueprint or sample of the item.

HARVEY HUBBELL, INC.

HIGHEST QUALITY WIRING DEVICES • MACHINE SCREWS

OVER 60 YEARS' EXPERIENCE in the manufacture of highest quality, rolled thread machine screws and special cold headed parts.

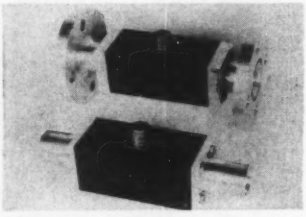
MACHINE SCREW DEPARTMENT BRIDGEPORT 2, CONNECTICUT

Circle 537 on Page 19

New Parts

(*Continued from Page* 233)

and an automatic temperature compensator. The electrodes and the thermistor for temperature compensation are embedded into the cylinder, which is encased in a metal housing. Automatic temperature compensator will function up to 400 F; without automatic



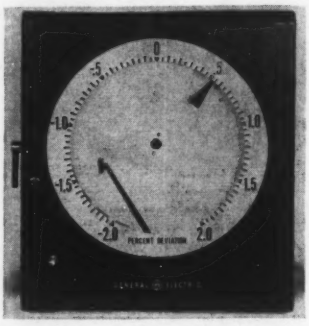
compensation, temperatures can be as high as 1000 F. Cell is used to determine the amount of impurities in free-flowing solutions. Available pipe sizes are ⅜, ½, ¾, and 1 in. Instrument Div., **Robertshaw-Fulton Controls Co.**, 2920 N. Fourth Street, Philadelphia 33, Pa.

Circle 730 on Page 19

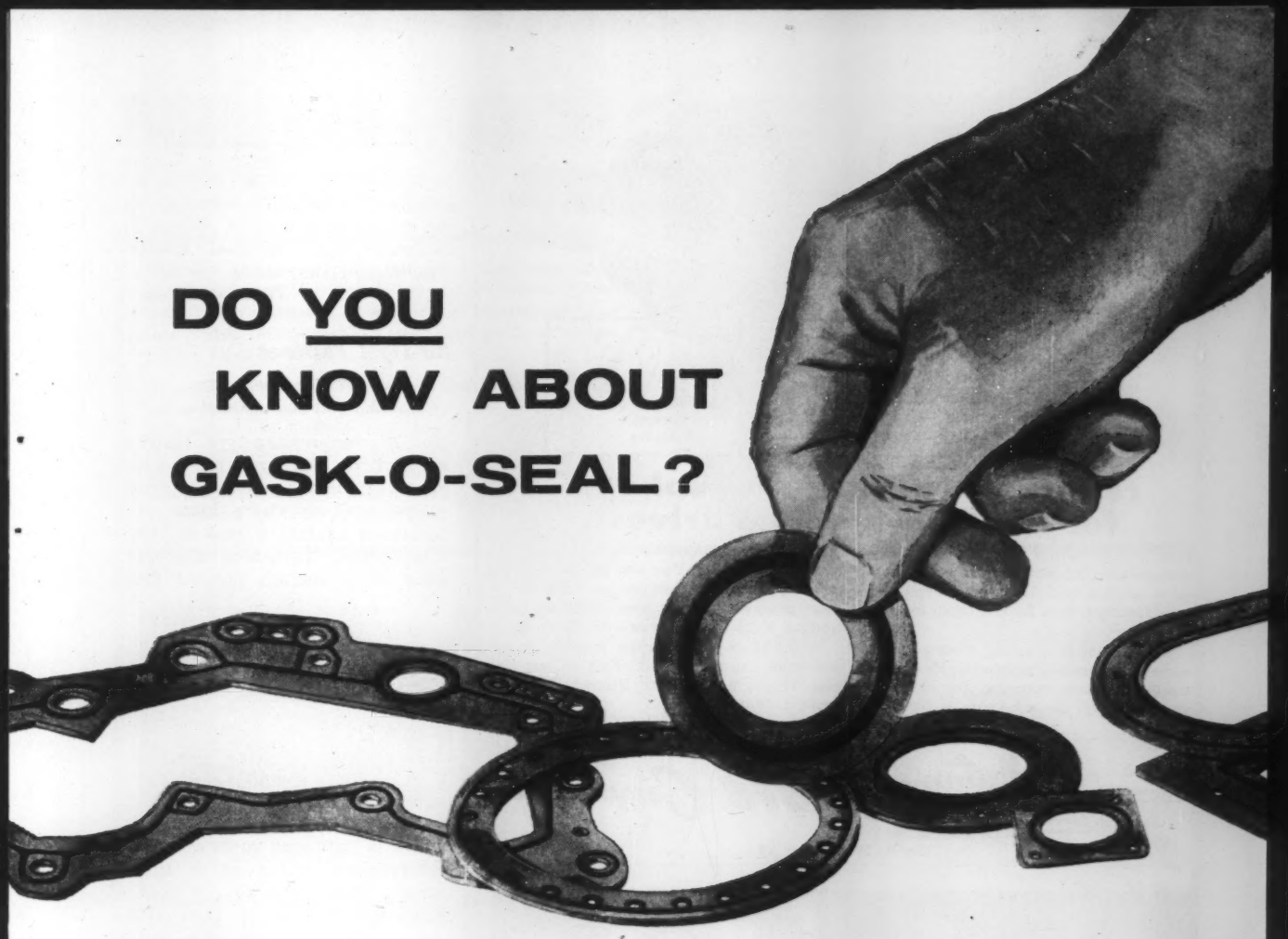
Speed-Deviation Recorder

has accuracy to 1/10 of 1 per cent

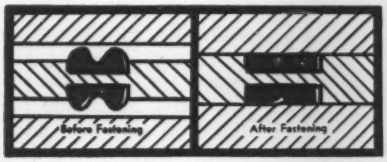
Type HE speed-deviation round-chart recorder is designed for use in processes where it is necessary to maintain constant speed, such as in the manufacture of nylon or other synthetic fibers, and in the steel, rubber, paper, and chemical industries. Unit has accuracy to 1/10 of 1 per cent. It indicates and records per cent deviation from a predetermined adjustable speed. Deviations as small as 0.01 per cent can be read easily on a highly expanded chart and scale. Recorder has high reliability in



DO YOU KNOW ABOUT GASK-O-SEAL?



The static seal that can not blow out!



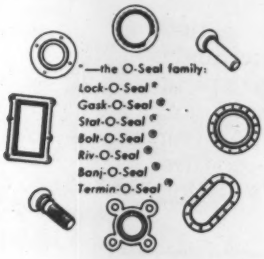
The above diagram is "typical" only. Gask-O-Seals are also made with one-side seals.

If you do not know about Gask-O-Seals look at these facts:

- Gask-O-Seals will seal practically any processable fluid . . .
- Gask-O-Seals can be re-used . . .
- Gask-O-Seals will seal at low or high pressures, vacuum or positive . . .
- Gask-O-Seals are available as standards and as specials in almost any configuration or to meet special requirements.

They are recommended for flanges, gear boxes, transfer cases . . . any place where truly efficient static seals are needed.

Note: A recent development of the Gask-O-Seal principle indicates effective sealing in the temperature ranges of −400° to +1000° for specific applications.

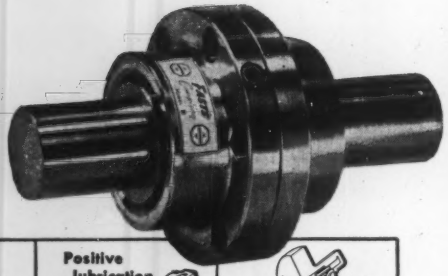


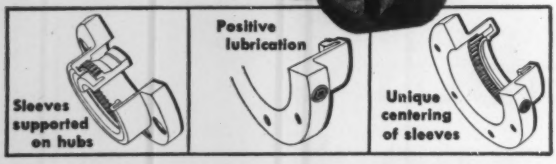
*—the O-Seal family:
Lock-O-Seal®
Gask-O-Seal®
Stat-O-Seal®
Bolt-O-Seal®
Riv-O-Seal®
Banj-O-Seal®
Termin-O-Seal®

FRANKLIN C. WOLFE CO.
Culver City, California
"sealing design specialists"
A DIVISION OF Parker APPLIANCE COMPANY
Hydraulic and fluid system components

Circle 538 on Page 19

FAST'S Model B Coupling





reduces downtime and upkeep for light-to-medium drives!

Now you can profit from the durability and economy of famous Fast's couplings in a smaller and lower-cost version—available in 3 sizes for shafts up to 2⅝" in diameter.

The Model B coupling gives you the same features that have made Fast's the world's leading coupling for over 35 years. You get the same trouble-free performance, longer service life and lower maintenance costs. You also get prompt delivery because stocks are on hand to meet practically every need. Free engineering service is also available.

Write today for more details to KOPPERS COMPANY, INC., Fast's Coupling Dept., 3512 Scott Street, Baltimore 3, Maryland.

Engineered Products Sold with *Service*

KOPPERS

THE ORIGINAL *FAST'S Couplings*

Circle 539 on Page 19

PHILLIPS SUB-MINIATURE RELAYS

Phillips relays are advanced-design subminiatures produced with the meticulous care required for service under severe conditions. Combining dependability, compactness, lightness and ruggedness. Proven by years of application. Write for literature on these and other relays, available in a permanent, three ring binder.

Phillips Control Corporation, Joliet, Illinois — AN ALLIED PAPER CORPORATION SUBSIDIARY — SALES OFFICES: NEW YORK - PHILADELPHIA - BOSTON - SAN FRANCISCO - DENVER - SANTA MONICA - WASHINGTON - WINSTON SALEM - CLEVELAND - DALLAS - SEATTLE - KANSAS CITY - ST. LOUIS - DETROIT

Circle 540 on Page 19

New Parts

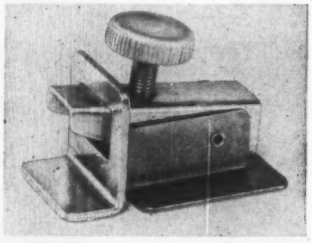
continuous operation, and is unaffected by vibration normally encountered in industrial plants. Industrial Dept., **General Electric Co.**, West Lynn, Mass.

Circle 731 on Page 19

Air-Tight Fastener

for use where doors are sealed against a gasket

No. 25 compression-type fastener is used for any air-tight, lightproof, or vibration-resistant application, such as where doors must be sealed against a gasket. Cadmium-plated fastening unit consists of a sliding, pivoted latch



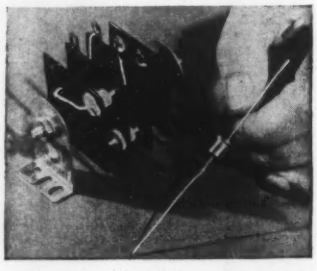
which is tightened down under the compressive action of a thumb screw. **Torit Mfg. Co.**, Walnut & Exchange Streets, St. Paul, Minn.

Circle 732 on Page 19

Silicon Rectifier Diodes

for all power applications

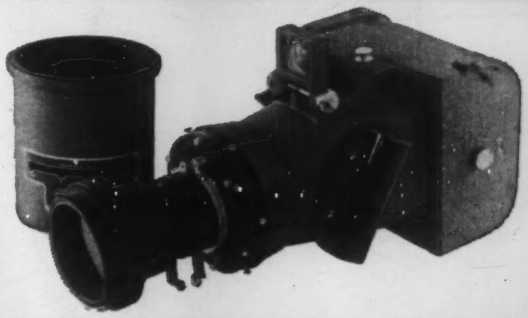
Three silicon power rectifier diodes are hermetically sealed units providing dc forward currents to 1.6 amp with maximum peak inverse voltage to 800 v. They are designed for all types of power applications. Maximum forward voltage drop at 1 amp and 125-C case temperature is 1.3 v. Maximum operating frequency is 50 kc. Rectifier case is the positive terminal. Type 305 has a stud base for through mounting, Type 320 has a pigtail base, and Type 321 has a

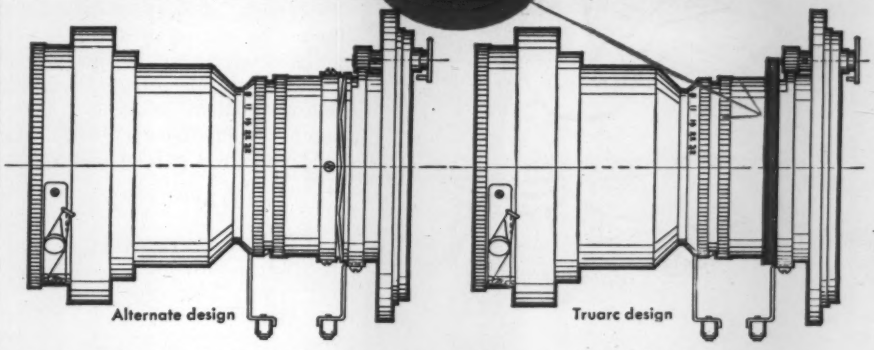


Waldes Truarc Retaining Ring eliminates 7 parts, saves $8.88 in sub-assembly of aerial reconnaissance camera

Gordon Enterprises, No. Hollywood, California, saved the Navy almost 1½ million dollars on 500 cameras. Gordon rebuilt new, efficient "CA" series out of Navy-owned obsolete models. Critical parts are now held together by Waldes Truarc Retaining Rings.

Truarc Rings are trouble-free, will not change position during operation. Accuracy is limited only by groove and ring dimension tolerances. And standardized Truarc Rings are quickly interchangeable in overhaul which now takes only 11 minutes, can be handled by unskilled technicians.





Truarc 5100-287 ring retains shutter speed adjustment mechanism on the Lens Adapter Plate Assembly which mounts and locks the lens and shutter assemblies accurately to camera body. Alternate design required retaining washer, spring, collar and 4 locking screws.

Weight Saving: 7.25 oz.

Assembly Time Saving: . . . . . 6½ min.

DOLLAR SAVINGS:

Material	**$ .93**
Fabrication	**6.88**
Inspection	**1.07**
Total	**$8.88**

Whatever you make, there's a Waldes Truarc Ring designed to save you material, machining and labor costs, and to improve the functioning of your product.

In Truarc, you get

Complete Selection: 36 functionally different types. As many as 97 standard sizes within a ring type. 5 metal specifications and 14 different finishes. All types available quickly from leading OEM distributors in 90 stocking points throughout the U. S. and Canada.

Controlled Quality from engineering and raw materials through to the finished product. Every step in manufacture watched and checked in Waldes' own modern plant.

Field Engineering Service: More than 30 engineering-minded factory representatives and 700 field men are at your call.

Design and Engineering Service not only helps you select the proper type of ring for your purpose, but also helps you use it most efficiently. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting . . . Waldes Truarc Grooving Tool!

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TRUARC®

RETAINING RINGS

WALDES KOHINOOR, INC.

47-16 AUSTEL PLACE, L. I. C. 1, N. Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.
Please send new, descriptive catalog showing all types of Truarc rings and representative case history applications. *(Please print)*

Name _____

Title _____

Company _____

Business Address _____

City _____ *Zone* ____ *State* _____

MD129

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

A TALENT FOR INVENTION: Leroy® Lettering Equipment—a K&E development—insures perfect neatness and uniformity, yet it is simple to operate and requires no special skill or training. One man can start a job and another finish it without any variation in lettering.

This K&E equipment comprises three basic, precision engineered parts: Leroy template, Leroy pen and Leroy scriber. Capitals, lower case, numerals, vertical or forward slanting letters can be drawn from a *single* template—an *exclusive* K&E feature. You can buy templates, pens, and scribers separately or in convenient sets.

Leroy templates offer a variety of alphabets, sizes and graphic symbols. Electrical, mathematical, mapping, geological and other symbol templates are available. Templates, with words or phrases that are frequently repeated, as well as templates with your own symbols, trade marks or designs, can be made to your order.

To save time and money in your drafting room specify K&E Leroy® Lettering Equipment. For other drafting or engineering equipment and materials also look to Keuffel & Esser Co.—your "Partners in Creating"—who have served engineering for 90 years.

KEUFFEL & ESSER CO. New York, Hoboken, N.J., Detroit, Chicago, St. Louis, Dallas, San Francisco, Los Angeles, Seattle, Montreal.

New Parts

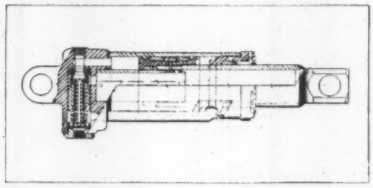
plain base without pigtail. The cells are also available in complete rectifier bridge assemblies. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

Circle 733 on Page 19

Hydraulic Cylinder

is dual-speed unit

Thrust-O-Matic cylinder provides alternating speed and power cycles in the same basic unit, employing a single pump and motor. Completely self-contained, it is equipped with automatic valving. Shift from low-power, high-speed stroke to high-power, slow-speed stroke is effected by means of spring-loaded valves in the head, responding to increases and decreases in system pressure. Unit is basically a three-chambered cylinder. Two high-speed chambers are located around



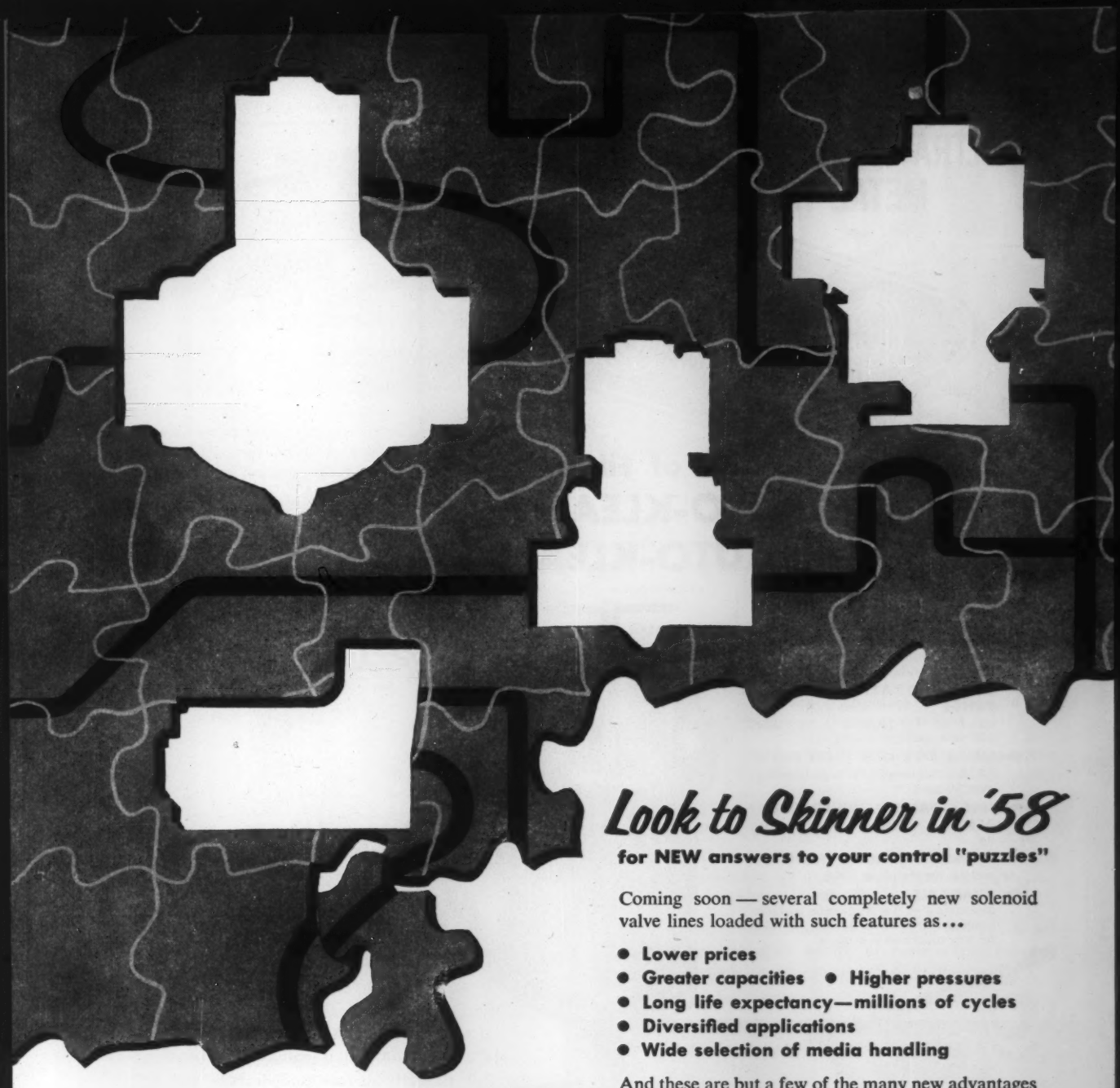
a third cylinder. Cylinder operates on the outer, high-speed chamber. When load increases, inner chamber becomes operative to provide maximum power at slower speed. When load drops, outer chamber becomes operative again. Opposing outside chamber provides high-speed retraction of the cylinder. **Crown Engineering Corp.**, 4700 Washington Ave., Houston 8, Tex.

Circle 734 on Page 19

Motor-Generator Sets

400-cycle units
have new exciter design

Motor, alternator, and armature of the direct-current field-pole exciter are mounted on a common shaft in redesigned 400-cycle motor-generator units. Design permits the exciter armature to be supported by the generator end bearing. Sleeve in the armature core fits over an extension of the main shaft, permitting two-bearing construction. Illustrated is a 15-kw, 400-cycle unit. Input is 25-hp, 220/440-v, three-phase, 60-cycle,



Look to Skinner in '58

for NEW answers to your control "puzzles"

Coming soon — several completely new solenoid valve lines loaded with such features as...

- **Lower prices**
- **Greater capacities** • **Higher pressures**
- **Long life expectancy—millions of cycles**
- **Diversified applications**
- **Wide selection of media handling**

And these are but a few of the many new advantages of Skinner's new solenoid valves. As always, of course, they'll be strictly manufactured to Skinner's highest-quality engineering standards.

Look for the announcements of Skinner's new valve lines in these pages throughout 1958. For advance information, write Dept. 42D.

Most important, these new valves will give you performance and applications that heretofore have not been possible!

Circle 543 on Page 19

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION

NEW BRITAIN CONNECTICUT

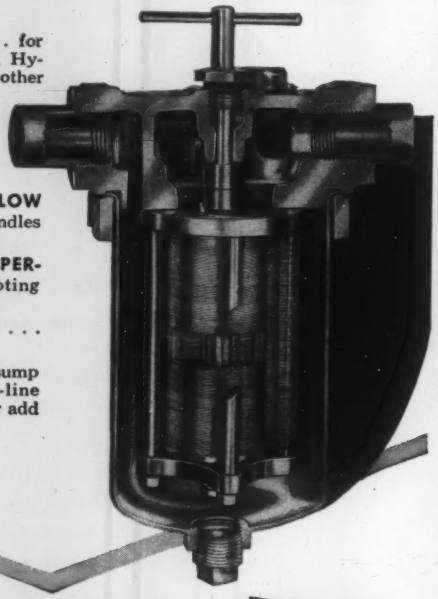
105 EDGEWOOD AVENUE

FILTRATION *Engineered** TO MEET METAL WORKING NEEDS

CUNO

a Complete Line of Filters including AUTO-KLEAN and SUPER AUTO-KLEAN

- **POSITIVE PROTECTION** . . . for Coolant Systems, Lube Oils, Hydraulic Fluids, Chemicals and other Process Fluids
- **WIDE FILTRATION RANGE** . . . with spacings from .020" to .0015" (40 microns)
- **SMALL SIZE with HIGH FLOW RATE** . . . unit only 12" high handles over 50 gpm
- **SELF-CLEANING WHILE OPERATING** . . . without interrupting flow
- **ALL-METAL CONSTRUCTION** . . . carbon or stainless steel
- **AVAILABLE** . . . for direct-sump mounting or for separate in-line housing. Easy to build into, or add to, any machine or system.



* Only Cuno offers you a truly complete line that includes *several* distinct types of filter media. Cuno also offers you a complete application engineering service through a Cuno Field Engineer conveniently located in your area. He is qualified to help you select the right filter type and model to solve your problems.

WRITE NOW FOR FULLY DESCRIPTIVE PRODUCT LITERATURE . . . *Free Auto-Klean Bulletins will be sent to you by return mail.*

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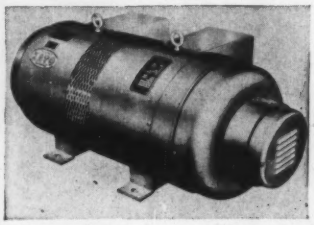
EDGE-TYPE, WIRE-WOUND, SCREEN, FIBER CARTRIDGE and POROUS METAL FILTERS

Filtration Engineers in Principal Cities

New Parts



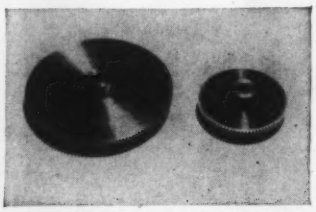
squirrel-cage induction motor. Output is 15-kw, 18.75-kva, 80-per cent power factor, 120/240-v, single or three-phase, 14-pole, 400-cycle revolving-field alternator. Unit operates at 3428 rpm. **Kato Engineering Co.**, 1415 First Ave., Mankato, Minn.

Circle 735 on Page 19

Antibacklash Gears

in ⅛ to ¼-in. bore diameters

Type P antibacklash spur gears are available in 24 to 200 pitch and have bores from ⅛ to ¼ in. in diameter. Materials are stain-



less steel, aluminum, and bronze. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, N. Y.

Circle 736 on Page 19

Thermal Ribbons

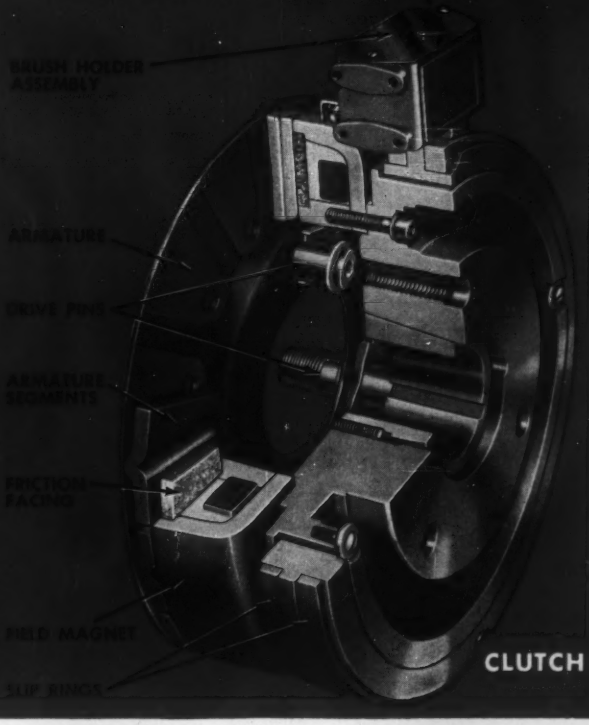
electrically detect surface temperature

Thermal ribbons are suited for use in aircraft, missiles, electronic equipment, and other applications. They detect electrically the temperature of the surface to which they are attached. Ribbons are extremely flexible and have negligible thermal lag. Resistance element of high nickel content alloy wire is encased in a flexible outer covering. Less than 0.020 in. thick, ribbon can be cemented to flat, cylindrical, or irregular surfaces. Self-adhering types are also available. Ribbons operate over wide temperature ranges, at

The New Dyna-torQ

MAGNETIC-FRICTION CLUTCHES, BRAKES, CLUTCH-BRAKES, CLUTCH-COUPLINGS

Are the Accurate, Trouble-Free Means of Controlling Power and Motion in Modern Stop-and-Go Machines



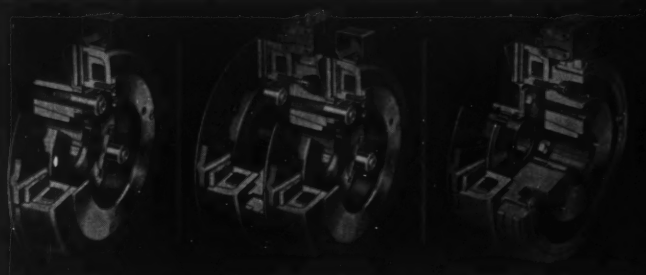
CLUTCH

The Eaton Dyna-torQ electro-magnetic friction units include a number of unique design advancements which provide longer life and superior performance with less maintenance. Check the following important advantages:

1. **Extremely Rapid Response in Clutching and Braking**—makes Dyna-torQ units ideally suited to a wide range of manual and automatic cycling applications.
2. **Smooth, Shockless Engagement**—permits rapid operation without backlash or chatter.
3. **Highly Effective Cooling**—maintains lower operating temperatures; permits fast, repetitive actuation.
4. **Self-Adjustment**—automatically maintains proper clearance between armature shoes and field magnet.
5. **Simple, Accurate Control**—manual or automatic; may be had to operate on 110, 220, or 440 volt, 60 cycle, alternating current.
6. **Low Maintenance Costs**—result from unique design features and superior quality of construction, assuring long operating life and minimum down-time.

Eaton Dyna-torQ Clutches and Brakes are electrically operated, disc-type friction units having two basic components: a field magnet and an armature. Torque is transmitted as the magnet pulls the armature into engagement. Because the pull of the magnet is direct without intricate linkage, and the movement of the armature is slight, Dyna-torQ units are capable of extremely rapid response in clutching or braking.

Ask us to tell you how these Dyna-torQ units will fit your equipment.



BRAKE CLUTCH-BRAKE CLUTCH-COUPLING

WIDE RANGE OF SIZES AND CAPACITIES

Send for Illustrated Descriptive Literature

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DYNAMATIC DIVISION
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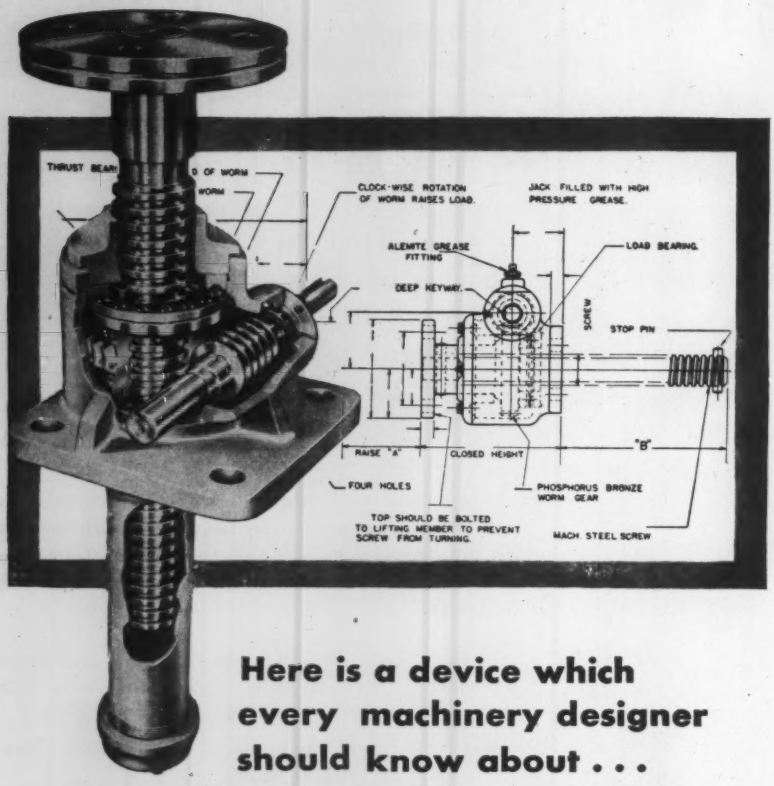
Circle 545 on Page 19



Here is a device which every machinery designer should know about . . .

DUFF-NORTON WORM GEAR JACKS

Duff-Norton worm gear jacks provide a purely mechanical means for accurate positioning of loads weighing as much as several hundred tons and maintaining them indefinitely without creep. They will operate in any position, and functioning as components of machinery and equipment they can raise and lower loads, apply pressure or resist impact. Jack capacities range from five to 50 tons. When two or more jacks are connected by means of shafting and mitre gear boxes they lift in unison, even when the load is unevenly distributed. They are available with standard raises up to 25 inches, and will provide exactly the same raise for years without adjustment. Worm gear jacks are suitable for operation at ambient temperatures up to 200°F.

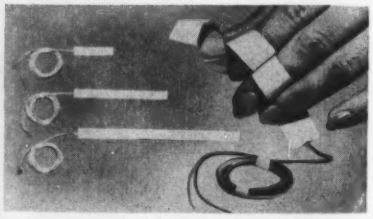
Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, arbor presses, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting bulletin AD-34-V, which includes drawings and full specifications.

DUFF-NORTON **Duff-Norton Jacks**

DUFF-NORTON COMPANY
P. O. Box 1889 • Pittsburgh 30, Pennsylvania
COFFING HOIST DIVISION: Danville, Illinois

Ratchet Jacks, Screw Jacks, Hydraulic Jacks, Special Worm Gear Jacks, Ratchet Hoists, Electric Hoists, Load Binders, Spur Gear Hoists

New Parts



high altitudes, and under severe physical conditions. **Minco Products Inc.**, 740 Washington Ave. North, Minneapolis 1, Minn.

Circle 737 on Page 19

O-Ring Compound

for use with fuel-gas equipment

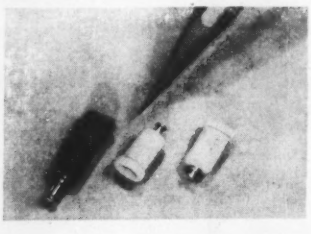
O-ring compound, designated 760-70, provides excellent service in low-pressure fuel-gas accessories and equipment, and in the equipment involved in the manufacture or distribution of bottled pressure gas. It is also used for seals with gasolines where service conditions are not too critical. The synthetic-rubber compound has high resistance to gases, oils, and gasolines. Material is for service in propane and butane gases, gasolines of all types, including automobile engine fuels, and for fuel oils, including No. 6. **Precision Rubber Products Corp.**, 3110 Oakridge Drive, Dayton 7, Ohio.

Circle 738 on Page 19

Test-Point Jacks

for shallow assemblies

Types SKT-2BC and SKT-5BC test-point jacks are shortened versions for use in shallow assemblies. They have identical dimensions, but take 0.080 and 0.090-in. diam pins or plugs, respectively. Bushing body diam is 0.185 in., 0.218 in. for the front face; overall length, including lug, is 7/16 in. Machined contact members of beryllium-copper gold flash over

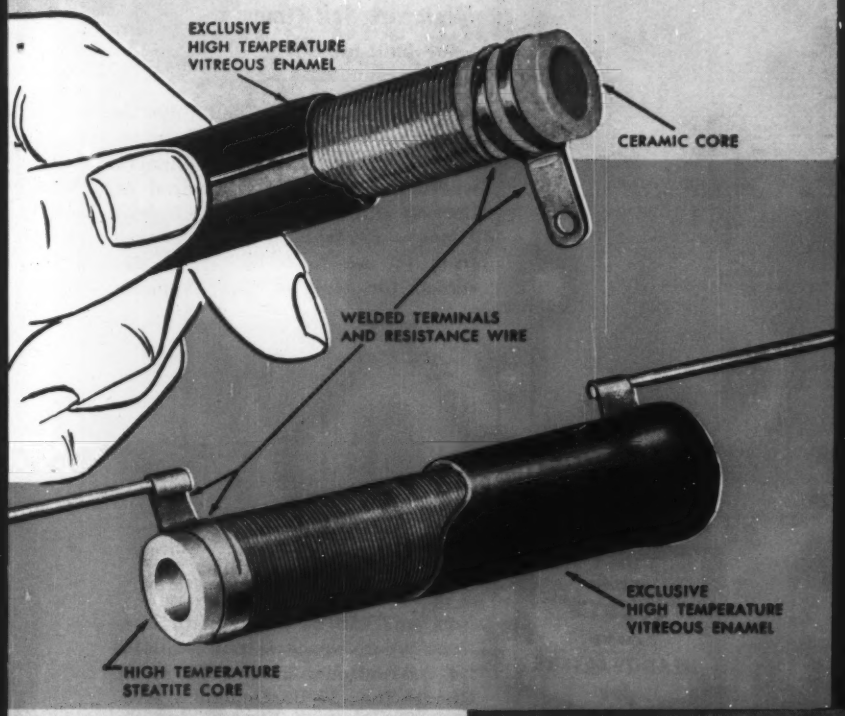


Circle 546 on Page 19

OHMITE®

WIRE-WOUND, VITREOUS-ENAMELED

POWER RESISTORS . . . *industry's most complete line*



WELDED RESISTANCE WIRE Ohmite Resistors have the resistance wire welded to the terminals instead of soldered or brazed. This provides a perfect and permanently stable electrical connection that is unaffected by vibration or high temperature.

WELDED TERMINALS Another Ohmite Resistor feature is the welded terminal band. The band is permanently held together around ceramic core by means of welding, providing a strong, permanent fastening.

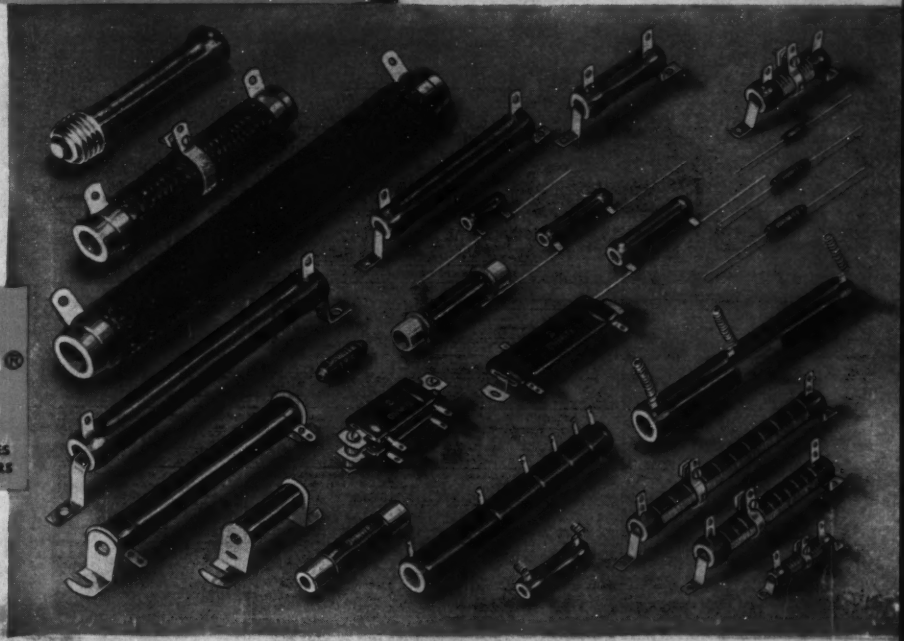
STRONG CERAMIC CORE This strong, rugged core has excellent electrical characteristics, and is unaffected by cold, heat fumes, or high humidity.

EXCLUSIVE HIGH TEMPERATURE VITREOUS ENAMEL This special-formula enamel was developed by Ohmite after extensive research. Its thermal expansion is properly related to that of core, terminal, and resistance wire.

Ohmite offers resistors in more than 60 sizes—ranging from 2½" diameter by 20" long to ¼" diameter by 9/16" long—to meet your exact requirements. MANY SIZES ARE CARRIED IN STOCK.

Ohmite offers the most complete line of wire-wound, vitreous-enameled POWER RESISTORS on the market . . . fixed, adjustable, tapped, noninductive, and precision resistors in many sizes, types of terminals . . . available in a wide range of wattages and resistances.

Write on company letterhead for Catalog No. 40.



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RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES
TANTALUM CAPACITORS • VARIABLE TRANSFORMERS

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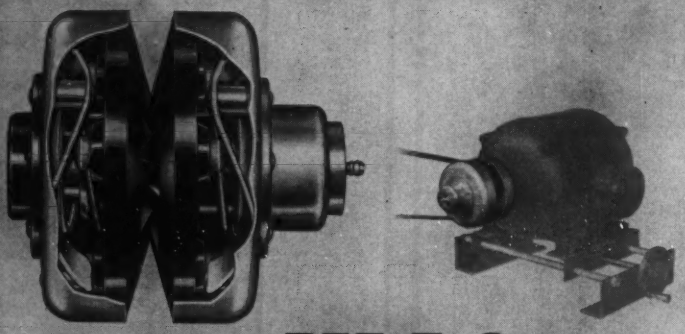
Circle 547 on Page 19

striving for SIMPLICITY?



here's how HI-LO helps

Design-wise, HI-LO automatic variable speed pulleys help you reduce complex design problems. Functionally, they're first choice of many design engineers for a wide range of applications. The simple, positive action of cam followers on cams is the mechanical action that takes place in maintaining the pitch diameter setting regardless of load—an exclusive feature of HI-LO pulleys. Springs in HI-LO pulleys are not driving members as in most spring-loaded pulleys, but serve primarily to keep the pulley faces in contact with the belt.

For *FREE* technical manuals with diagrams, descriptions of applications and other power transmission data, write:

Equipment Engineering Company

2855 Columbus Ave., Minneapolis, Minnesota

Circle 548 on Page 19

Bonded to Metal by GOSHEN RUBBER

make GOSHEN your HEADQUARTERS for

NATURAL SYNTHETIC & SILICONE RUBBER PARTS AND COMPONENTS

Custom-Made TO YOUR EXACT SPECIFICATIONS

When you need trouble-proof adhesion between a rubber compound and metal, count on GORBOND, Goshen's exclusive bonding process. It's tops for bonding rubber and metal to meet today's exacting tolerance, materials and performance specifications. We'll gladly work with you on even the toughest bonding problem.

ASK FOR LITERATURE

GORBOND Technical Bulletin No. 9, and this 8-page brochure tell how Goshen Rubber can help you. They're free.

This is GORBOND

. . . this combining of rubber and metal, in a unit having the desired properties of strength, resiliency, insulation, and longevity . . . to meet specific service requirements.

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1712-7 S. TENTH ST. GOSHEN, INDIANA

See our catalog in Sweet's Product Design File

Circle 549 on Page 19

New Parts

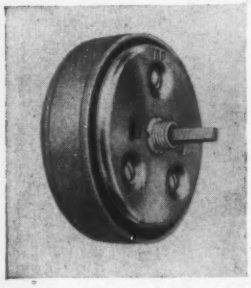
silver provide a firm grip for inserted pin or plug. Teflon body provides excellent insulation for a wide range of climatic and operating conditions. Both types are available in eight RETMA code colors. **Sealectro Corp.**, 610 Fayette Ave., Mamaroneck, N. Y.

Circle 739 on Page 19

Miniature Bell Timer

for built-in timer applications

Miniature Mark-Time bell timer is adaptable to a variety of industrial equipment or appliances where a bell signal is desired at the end of a specific period of time. Timer is available in timing ranges from 60 sec to 5 hr. It is designed for built-in timer application, and can be mounted in locations where space is not available for conventional-sized units. **M. H. Rhodes Inc.**, 30 Bartholomew Ave., Hartford 6, Conn.



Circle 740 on Page 19

Air-Pressure Switches

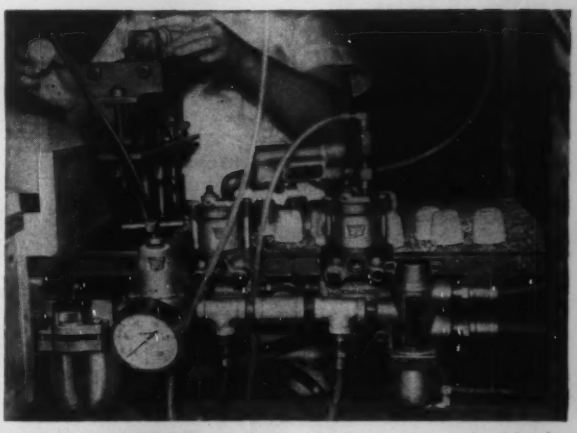
operate in dc or single-phase ac circuits

Series RG18040 switches are for use in all types of airborne radar pressurization sets, and are intended for pressure-level control by direct connection to the air pump motor electrical circuit. They also operate low-pressure warning lights and interlock controls. Switches are single-pole, double-throw units, providing control under increasing or decreasing pressures, and operate in either dc or single-phase ac circuits with current load of 10 amp resistive. They perform without chatter over full operating pressure range, at any implied vibration frequency

***Progress** in designing air systems:*

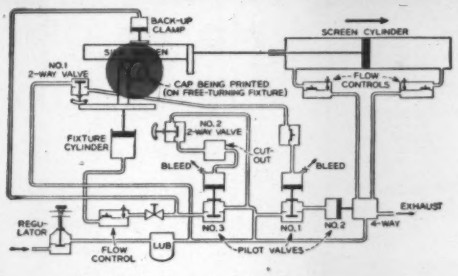
Here's an automating idea: Schrader Air Products in a precision programming operation

PROBLEM: To print bottle caps accurately at high speed.

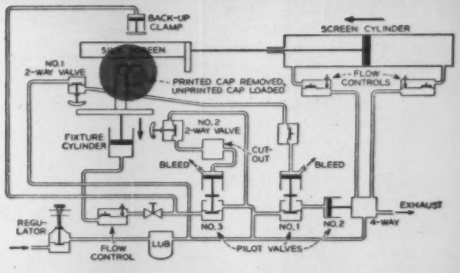


PROVED IN OPERATION: Prominent silk screen printer puts Schrader products to work at a profit.

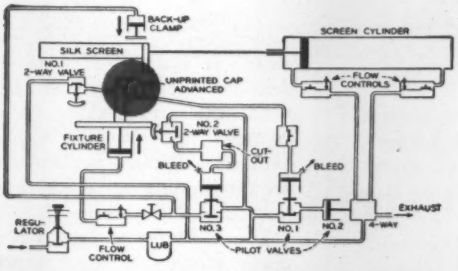
SOLUTION: Adapt Schrader Air Products to silk screen printer.



Fixture holding plastic cap on freely rotating fixture is held up against silk screen by Schrader cylinder. Another Schrader cylinder pushes screen sideways over the freely rotating cap, imparting the printed message.



Fixture with printed cap moves down, back-up clamp retracts and screen cylinder returns to initial position. Operator removes printed cap and loads another unimprinted cap.



Schrader cylinder advances fixture upward loaded with unimprinted plastic cap. Back-up clamp starts downward toward silk screen. And cycle starts all over again.

This is but one precision operation of the limitless operations which can be controlled *fast, economically* and *accurately* by Schrader Air Products. The hundreds of different units in Schrader's complete line can be employed alone or in combination to perform stamping, programming, forming, measuring, squeezing—other jobs too! And wherever air is used, economy is basic.

Test the performance of all your machines against the efficiency that could be achieved with air. Schrader engineering facilities are available to help you. Outline your problem to us and assistance will be prompt. Right now, mail the coupon.

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QUALITY AIR PRODUCTS

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476 Vanderbilt Avenue, Brooklyn 38, N. Y.

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Address_____

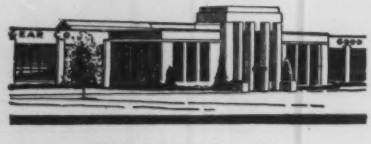
EGYPTIAN DEITIES, Fatimas and Harems

No, these aren't out of Arabian Nights, but were contemporaries of Murads, Condaxes, Richmond Straight Cuts and Sweet Caporals — all popular cigarettes of fifty years ago. Their sale was still illegal in several states, but where you could buy them they cost from 10c to 15c a package of 20 down south (where the popular brands used Virginia tobacco) to 15c to 25c a box of 10 up North (where straight Turkish tobaccos and cork tips were favored). They were a relatively new "fad" and considered by many to be objectionably "sporty".

In the ensuing fifty years the popular attitude towards cigarettes has changed considerably — and so have the cigarettes. As cigarette manufacturers have learned how to improve their product over the years, so have we learned a *lot* more about making better gears than anyone knew back in 1907. In fact, we've made a lot of progress just in the past ten or fifteen years. What about *your* present source of custom gears? A re-examination may show that it will pay you now more than ever to rely on Cincinnati Gear for your custom gear requirements.

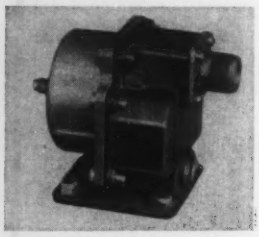
THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
Fifty Years of "Gears—Good Gears Only"

CINTI®



Circle 551 on Page 19

New Parts



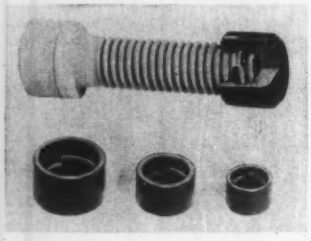
from 10 to 500 cps, and 10 g acceleration. Pressure setting can be adjusted externally. Pressure adjustment ranges are provided from 24 to 100 in. Hg absolute, and from 0 to 25 psi gage. **Lear-Romec Div.,** Lear Inc., Elyria, Ohio.

Circle 741 on Page 19

Toggle Pads

for use on any standard screw

Screwzon swivel toggle shoe pads can be used on any standard or stock screw without machining or altering. Spring insert in each pad holds the screw on, but permits swivel pad to turn easily, with universal action of 8 deg in any direction. Toggle pads are avail-



able in 5/16, 3/8, and 1/2-in. sizes in hardened, black-oxide and unhardened, cadmium-plated types. **Standard Parts Co.,** 1010 Broadway, Bedford, Ohio.

Circle 742 on Page 19

Blower Unit

for flow ranges from 500 to 1500 cfm

Radiax mixed-flow blower is a symmetrically constructed, direct-drive unit with power and pressure characteristics suited for furnace and air-conditioner applications. It is available in four models covering flow ranges from 500 to 1500 cfm against typical back pressures. Flat power curve per-

Y MOTOR OFFERS ADAPTABILITY

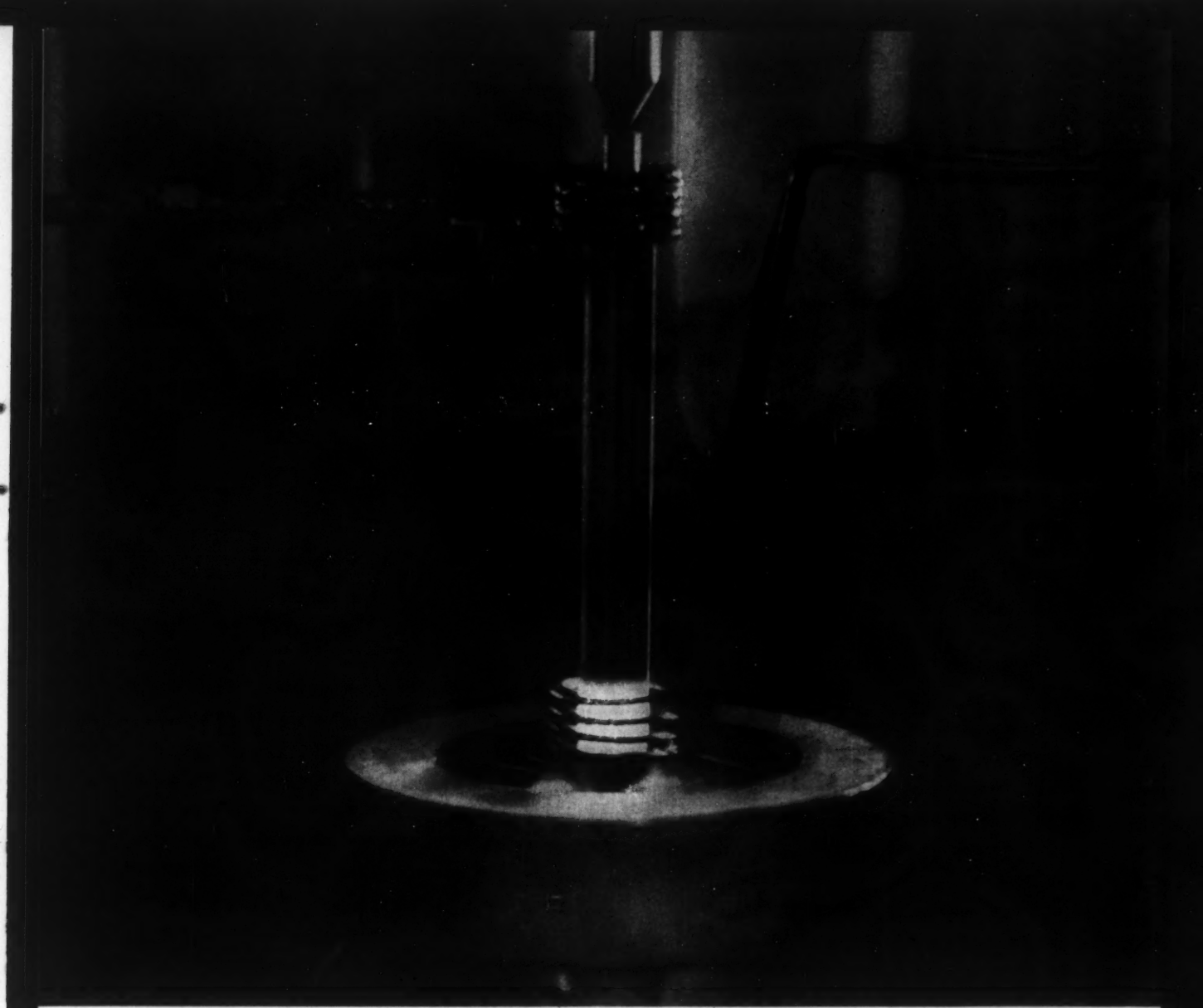
This compact 4-pole shaded pole induction motor gives you a wide choice of horsepower, voltages, frequencies, starting torque, mounting provisions and other modifications. Standard models have horsepower ratings from 1/30 to 1/200 hp; free speed 1700 rpm; load speeds 1400 to 1700 rpm; 115v, 60 cycle, CW or CCW; high or low starting torque. Mounting provisions are 2 or 4 stud, flat strap, or saddle strap. Modifications include end or side ventilations; internal fan. Other voltages and frequencies are available. Typical applications are for vending machines, fans, aquarium pumps, etc.

The Y Motor is just one of many models in the comprehensive line of Heinze Sub-Fractional Horsepower Motors and Blowers. Send us your product and specifications. Heinze Engineers will adapt a motor at no obligation. Or write for catalog.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.

Sub-Fractional Horsepower Motors and Blowers

Circle 552 on Page 19



Ketos shaft being induction hardened to Rockwell 55-56, while ends remain soft for final machining. Photographed at Control Instrument Co., Inc., Brooklyn, N. Y.

KETOS has wide hardening range with minimum volume change...

Ketos is a low priced alloy tool steel that can be hardened from low temperatures with practically no volume change. It has deep hardening qualities, and a fine grained structure, that make it desirable for many production parts.

That's why nondeforming Ketos is well suited not only for most tool steel applications such as gauges, dies, and taps but also for close-tolerance, wear-resistant parts like the actuator bar shown in the induction heating unit above. The thin contact edges of this particular part withstood a "life test" of over 4-million high speed blows. No other steel tested lasted more than 1-million cycles before it chipped and failed.

If Ketos sounds like the steel you should be using, call your nearby Crucible warehouse. Stocks of Ketos and dozens of other special tool steels are large, delivery fast. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

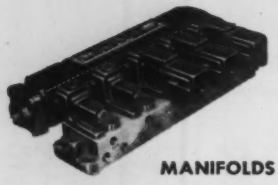
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

Circle 553 on Page 19

Specify **NUMATICS VALVES**
... there are no "equivalents"



MANIFOLDS

DSA34 valves mount interchangeably with all other SA Series air valves on Numatics air and conduit manifolds.

LINE VALVES

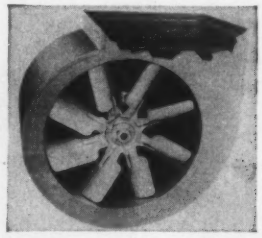
Numatics makes a complete line of foot-mounted, line-mounted 2- and 3-way valves, too. Ask for Bulletin #4000.

Today's control demands, particularly in automation applications, require a host of unusual air circuits . . . emergency stop inching circuits, dumping both ends of cylinder to exhaust, pressurizing both cylinder ports, to mention a few. The valves for jobs like these? Numatics spring-centered DSA34 valves . . . the valve series that gives you split-second response, takes pressure surges without sticking or fluttering. Numatics DSA34 valves are offered, what's more, in a wider variety of sizes and actions than any similar valves now on the market. Want more details? Send for Numatics new Bulletin #558A on unusual circuits using 3-position valves.

NUMATICS, Inc.

HIGHLAND, MICHIGAN Dept. MD

New Parts



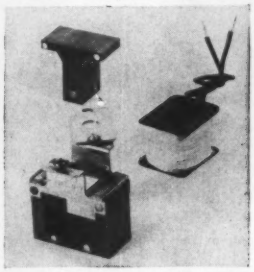
mits impellers to run at any operating point with the same motor. Motor need not be changed for operation in another system. Both motor and fan are resiliently mounted. **Torrington Mfg. Co.,** Torrington, Conn.

Circle 743 on Page 19

Industrial Solenoids

permit quick coil change without use of tools

Series S ac short-stroke industrial solenoids are available in five models giving 3 to 20 lb force at ½-in. stroke. They are available in push or pull types with either end or side-mounting plates. Coils can be changed in position quickly, since no tools are needed. Slipping the plunger out permits immediate replacement of coil. Large



plunger striking surface reduces load concentration, increasing solenoid life. **Ex-Cel Coil Co. Inc.,** 2832 E. Grand Blvd., Detroit 11, Mich.

Circle 744 on Page 19

Reciprocating-Shaft Seal

withstands temperatures to 575 F at 4000 psi

Reciprocating - shaft, nonmetallic seal uses Teflon for sealing. Teflon, machined to a wedge shape, is compressed against the shaft. Brass membranes or spacers separate inner and outer wedges to

Circle 554 on Page 19

Circle 555 on Page 19→

Allen-Bradley Line of MOTOR CONTROL *includes Both!*

D.C.

A.C.

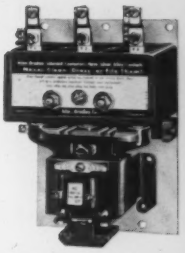
RELAYS AND CONTACTORS

Bulletin 200, Type G Relay. Rated: 5 amp, 64 v; 2 amp, 125 v; 0.5 amp, 250 v.

Bulletin 202 Contactor, Size 2, 1 Pole. Rated: 50 amp, 115-230 v.

D.C. relays are made with up to 8 poles. Also universal types, having contacts changeable from N.O. to N.C.—or vice versa—by merely reconnecting the terminals. Up to and including the 150 ampere rating, D.C. contactors are of the solenoid type; beyond this rating, up to and including 600 amperes, the clapper type construction is used.

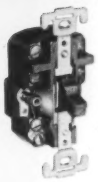
Bulletin 700, Type C. Rated: 10 amp, 550 v max.



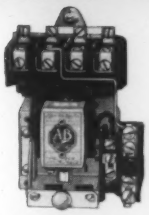
Bulletin 702, Size 2, 3 Pole. Rated: 50 amp, 550 v max.

A.C. relays are made in different types for various applications, with up to 8 poles. The universal type, having contacts changeable from N.O. to N.C.—or vice versa—is very popular. The A.C. solenoid contactors, made in 9 ratings up to 900 amp, 550 v max., will satisfy any service requirement. Silver alloy contacts are used throughout the D.C.-A.C. solenoid relay and contactor lines.

ACROSS-THE-LINE STARTERS



Bulletin 600, Form 52, double pole only, open type. Max rating: ¾ hp, 115-230 v.



Bulletin 209, Form 2. Max rating: 1½ hp, 115 v; 2 hp, 230 v.

D.C. manual starters have a rugged, snap action mechanism that prevents contact "teasing" and thus prolongs contact life. D.C. manual and solenoid starters have maintenance free, double break, silver alloy contacts. Motor overload protection is reliable.

Bulletin 600 in general purpose enclosure, complete with reliable overload breaker. Rated: 1 hp, 110-220 v.

Bulletin 709, Size 1. Rated: 7½ hp, 220 v; 10 hp, 440-550 v. Same general construction for max ratings of 300 hp, 220 v; 600 hp, 440-550 v.

All Allen-Bradley A.C. motor control is equipped with silver alloy contacts which are always in good operating condition. Because all A-B solenoid starters have only one moving part, trouble free performance and long life are automatically assured. It is the basic reason for Allen-Bradley's "quality" reputation.

MORE ON NEXT PAGE!

A-B QUALITY

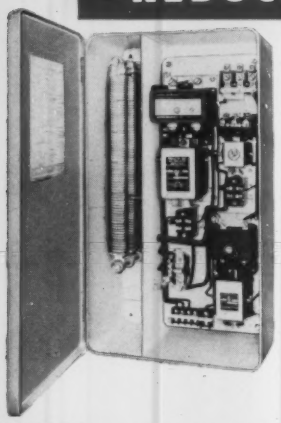
Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

. . . and more

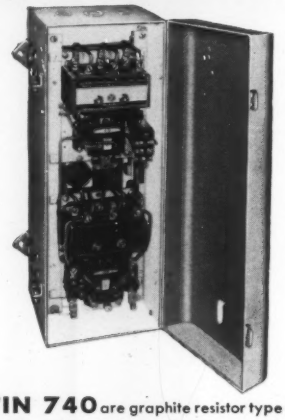
Allen-Bradley MOTOR CONTROL

D.C. | A.C.

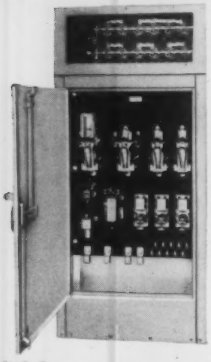
REDUCED VOLTAGE STARTERS



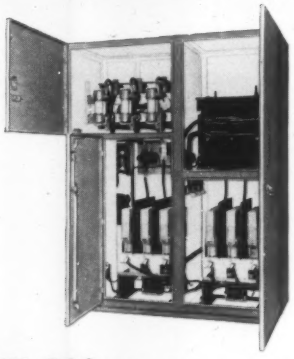
BULLETIN 267 are time limit, resistor type starters for automatic acceleration of constant speed shunt and compound wound D.C. motors. Solenoid contactors used up to and including Size 4 ratings. Max ratings: 75 hp, 115 v; 150 hp, 230 v.



BULLETIN 740 are graphite resistor type starters for automatic acceleration of squirrel cage A.C. motors. Made with 1 or 2 points of acceleration. Can provide velvet smooth acceleration for squirrel cage motors. Max ratings: 200 hp, 220-440-550 v.



BULLETIN 268 are time limit resistor type starters for automatic acceleration of adjustable speed shunt and compound wound D.C. motors. Designed for heavy duty service. Both Bulletin 267 and 268 starters available with or without dynamic braking feature, and also for reversing service. Max ratings: 75 hp, 115 v; 150 hp, 230 v.



BULLETIN 983 high tension starter illustrated above is of the reactor type, intended for starting synchronous motors. Available as an autotransformer reduced voltage starter; also in the across the line construction. The heavy duty, solenoid air break contactor assures long, trouble free life. Max ratings: 1500 hp, 2300 v; 2500 hp, 4600 v. at 0.8 P.F.

The Allen-Bradley *quality* line is *not* limited to alternating current motor control. A companion line of direct current motor control is available with the same outstanding *quality* . . . the same reliability . . . the same ability to "take it." Both lines are described and listed in our latest A-B Handy Catalog, and our trained field engineers will also be glad to help you with your control problems.

You cannot make a mistake when you insist on Allen-Bradley control.

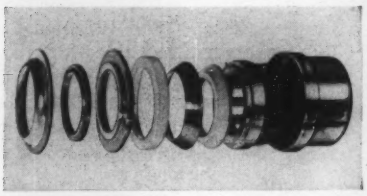
ALLEN-BRADLEY

SOLENOID MOTOR CONTROL

QUALITY

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

13-57-MR



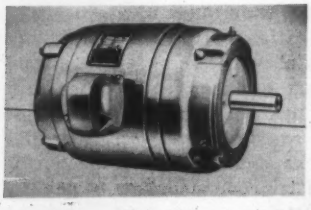
prevent welding. Seal withstands temperatures to 575 F at 4000 psi. **Skinner Seal Co.**, 3001 Sutter St., Santa Ana, Calif.

Circle 745 on Page 19

Footless Motor

for direct connection to driven equipment

Uniclosed footless motor, designed for direct connection to driven equipment, is supplied with a NEMA C bracket for automatic alignment. Motor is available in ratings from 1 to 30 hp. Deflector directs air and deflects water. Cast-iron, one-piece frame is heat-treated to prevent warpage, and is completely dripproof. Windings are asbestos protected. Split-type conduit box for easy access to motor leads can be located above, below,



or on either side of motor. Rotors are solid cast and dynamically balanced. **U. S. Electrical Motors Inc.**, Box 2058, Terminal Annex, Los Angeles 54, Calif.

Circle 746 on Page 19

Silicon Transistors

are for use in medium-power circuits

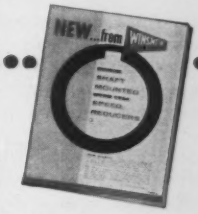
Two diffused-base silicon medium-power transistors have dissipation ratings of 4 w at 25-C and 1 w at 150-C case temperature. Both transistors have an operating range of −65 to 200 C. They are well adapted to high-temperature switching applications because of high peak currents. Units are encased in short, round-welded packages and differ only in collector-

NEW... from WINSMITH SPEED REDUCERS

SHAFT MOUNTED WORM GEAR SPEED REDUCERS

SERIES "ST" Torque Arm Type

SERIES "SF" Flange Mounted Type



Now you can specify Winsmith performance, dependability and economy for applications requiring a shaft mounted speed reducer.

The new Winsmith "ST" and "SF" series require less space than conventional models because they eliminate the need for couplings and bed plates. Both series are currently available in three sizes... in ratios from 7½:1 to 77:1... horsepower from .63 to 8.82... maximum output torque range from 816 to 7678 in. lbs.

These new shaft mounted models also embody all the advanced engineering and construction features that make Winsmith Speed Reducers first choice for any application from 1/100 to 85 h.p.

WRITE... FOR NEW CATALOG

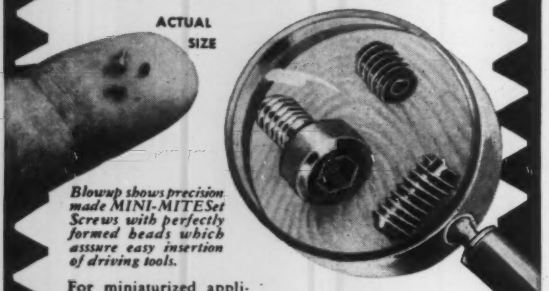
For all the facts and complete technical data on Winsmith Shaft Mounted, Worm Gear Speed Reducers, write today—on your company letterhead, please—for Catalog No. SM-57.

WINSMITH, INC. 76 Elton Street, Springville, (Erie County), N. Y.

Circle 556 on Page 19

FREE TEST SAMPLES Show How
MINI-MITE
miniaturized SET SCREWS
CUT YOUR COSTS!

ACTUAL SIZE



Blowup shows precision made MINI-MITE Set Screws with perfectly formed heads which assure easy insertion of driving tools.

For miniaturized applications Setko MINI-MITE Set Screws can cut your costs in four important ways. *Reduces initial cost,* no extra charges are incurred because of special design. *Increases production rates* because MINI-MITES are made with watch makers precision, threads mesh precisely—insert perfectly. *Cuts down on rejects* in sub or final assembly because of consistent uniform quality. *Immediate availability* in Slotted, Socket and Socket Cap types in sizes #0, #1, #2 and #3 and in a wide selection of metals, finishes, lengths and points to choose from.

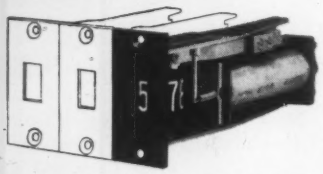
FREE TEST SAMPLES *Send Today* for your Free test samples of MINI-MITES or send your specifications and we will send samples.

214

Set Screw & Mfg. Co.
28 Main Street, Bartlett, Illinois

Circle 557 on Page 19

SODECO's *New* Type 1TD
Electric Impulse Counter—
for: NORMAL COUNTING...
TRANSMISSION OF A NUMERICAL INDICATION
REMOTE PRESETTING FOR PREDETERMINING CONTROL



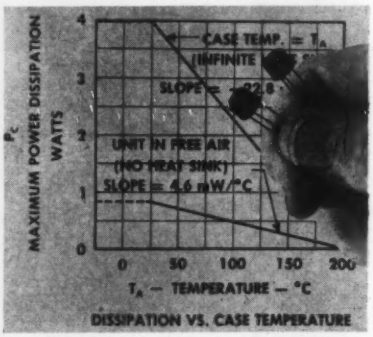
You can use these rugged single decade counters independently as decades or interdependently as a multi-digit counter to get practical solutions to an extremely wide variety of counting problems. Ten different contact arrangements are available to solve a number of problems. For example, an interesting application is the use of any number of decades as a remote predetermined counter in which any preselected number can be set up quickly from a remote location and made to operate a signal at either or both locations when the count returns to zero. In this application, if desired, the preselected figure could be set up from a punched card. The counters are small, measuring only ⅞" x 1¾" x 4⅜", and are suitable for flush mounting. Fast, models are available with speeds up to 25 impulses/second. Power requirements are low—permitting their installation in electronic circuits. Long lived, tests indicate certainty of operation up to at least 50 million impulses.

Complete technical data is available, including circuitry recommended for a wide range of use. Write for Bulletin 60.

LANDIS & GYR, INC.
45 West 45th Street, New York 36, N. Y.

New Parts

to-base and collector-to-emitter voltage ratings. The 2N497 is a 60-v transistor, suitable for use with 28-v power supplies employed in military aircraft. The 2N498 is a 100-v device for use in higher voltage applications, such as servo



amplifiers and regulated power supplies for missile applications. **Texas Instruments Inc.**, P. O. Box 312, Dallas, Tex.

Circle 747 on Page 19

Thermoplastic Material

has high tensile strength

Delrin is a thermoplastic material which can be molded or extruded for a wide range of engineering applications. It is a tough, rigid material with high tensile strength, high melting temperature, dimensional stability, and resistance to deformation under stress. Applications include automobile parts, industrial machinery, packaging, electrical equipment and appliances, pipe, and plumbing fixtures. Plastic is odorless, white, and opaque. It can be compounded into a range of colors. Material has a hard, smooth surface, and in many cases makes a good bearing material without lubrication. **E. I. duPont de Nemours & Co. Inc.**, Wilmington 98, Del.

Circle 748 on Page 19

Cable Clamp

for large-diameter coaxial cable

One-piece, ringlike clamp with two U-shaped lugs is used to attach solderless connectors to large-size coaxial cable. When slipped in place over the cable and fitting, it is crimped tight by squeezing the

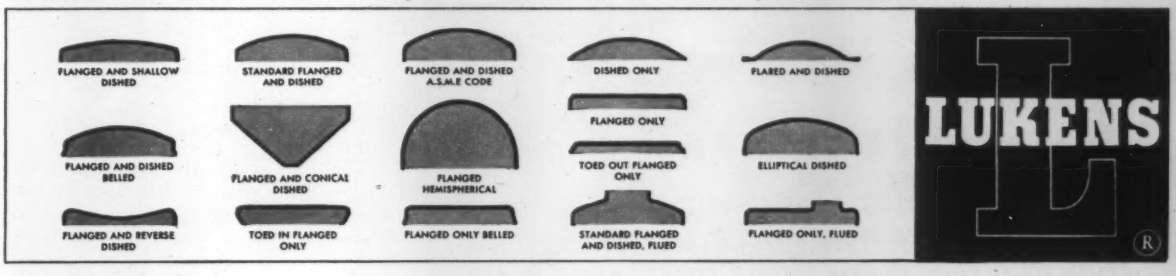
Air conditioning heat pumps are made stronger and lighter by General Electric with economical Lukens pressed heads.

Ingenuity pays off... designing with Lukens heads

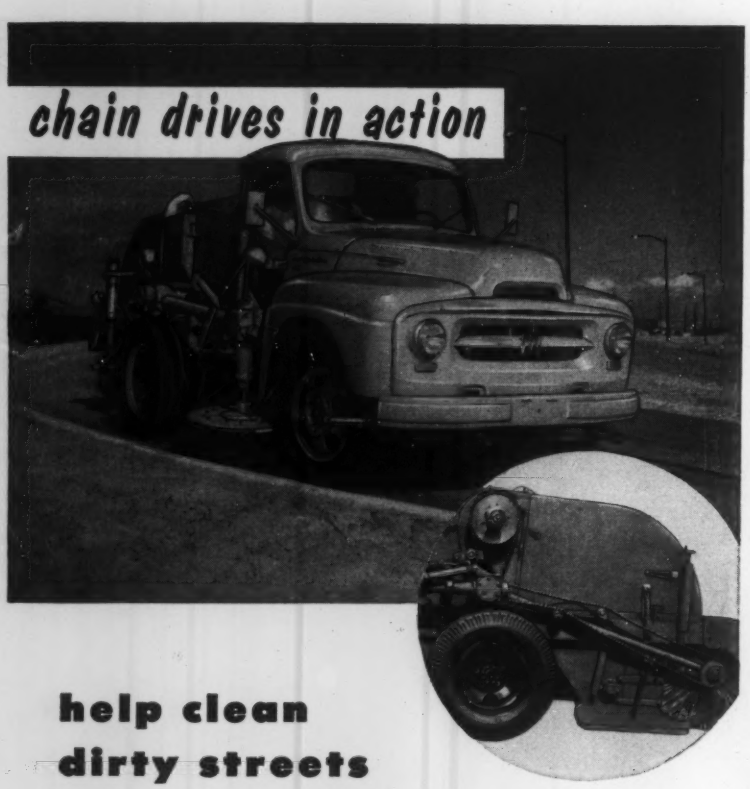
■ Ingenuity ... and four Lukens heads ... meant considerable savings and increased strength in these General Electric Weathertron heat pumps. Designers at General Electric's Air Conditioning Division, Bloomfield, N. J., eliminated the need for expensive castings by making the pump compressor housings of Lukens heads, pressed to extremely fine tolerances. Fitted together they result in stronger and lighter units.

Whether you make heavy or light machinery, valves, wheels, or pumps, Lukens heads may be the answer to a costly fabrication problem. Designers have been using them for years. Lukens' fifty-five years as the leading producer of spun and pressed heads for many applications are at your service. Write today for Catalog 933, *"Pricing and Engineering Data,"* Lukens Steel Company, Coatesville, Pennsylvania.

Lukens Offers the World's Broadest Line of Spun and Pressed Heads of Carbon, Alloy and Clad Steels



Circle 559 on Page 19



help clean dirty streets

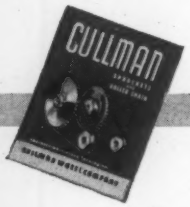
Around sharp corners on highways, parks, streets, alleys, Mobil-Sweepers cut street-sanitation costs 45%. And, do it with low maintenance expense. These efficient vehicles, built by the Conveyor Company in Los Angeles, eliminate extra pick-up and hauling equipment. They sweep from 1½ to 10 m.p.h. . . . carry away full loads at truck speeds. And, reduce street-sanitation to a simple, safe, one man operation.

To insure such performance Cullman chains and sprockets are used throughout. They rotate the sweeping brooms and drive the conveyor that feeds dirt into the hopper. Operating under wet or dry abrasive conditions they overcome shock loads, extend equipment service life, lower upkeep costs.

here's how chain drives can work for you . . .

On your products too, Cullman chains and sprockets can achieve similar advantages, help deliver top performance. Next time you're faced with a power transmission problem write direct or call in a Cullman man. He'll be glad to assist you . . . and recommend the right chain drive for your job.

For the full story on the Cullman power transmission line — roller chains, sprockets and flexible couplings, write today for catalog No. 51, or see your local Cullman Distributor.

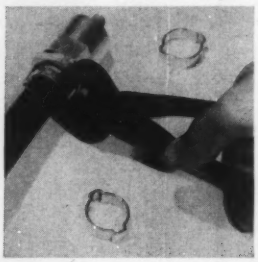


cullman
POWER TRANSMISSION
ROLLER CHAINS AND SPROCKETS

REPRESENTATIVES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES
CULLMAN WHEEL COMPANY, 1336 ALTGELD STREET, CHICAGO 14, ILLINOIS

Circle 560 on Page 19

New Parts



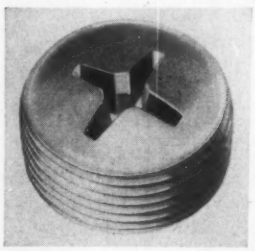
parallel sides of the lugs together with pincers. Clamp has a nominal diameter of ⅞ in., and is zinc-coated SAE 1010 steel. It is 0.35 in. wide with a wall thickness of 0.059 in., to provide rigidity and support to ends of cable. Clamp is available in 20 sizes from ¼ to 2⅝ in. ID, and in larger sizes on request. **Circle Clamp Corp.,** 39 Broadway, New York 6, N. Y.

Circle 749 on Page 19

Pipe Plugs

are cross-slotted, headless units

Slip-Proof pipe plugs are cold-rolled, cold-formed, dryseal-threaded units which adapt themselves readily to automation. They are available in sizes from 1/16 to 1 in. in steel, aluminum, brass, stainless steel, and everdur. The cross-slotted,



headless units are furnished in breather vents with porous bronze insert, or permanent Alnico magnet attached. **Pipe Plugs Inc.,** Wellington, Ohio.

Circle 750 on Page 19

Subminiature Switch

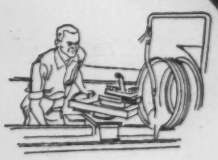
has overtravel plunger actuator

USMJ-1 subminiature switch is designed to provide the advantages of panel mounting plus overtravel plunger actuator. It mounts in a ¼-in. hole and fits into back-of-

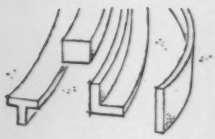
WHAT ARE AMWELD FLASH WELDED RINGS?

They are rings formed, flash butt-welded, and shaped into the finest quality circular weldments available.

They are rings that offer savings of critical materials. Bar stock formed and flash welded uses considerably less material than rings made by other methods.



They are rings that offer additional manufacturing savings. Since the rings are closer to the desired finished cross section, it is less expensive to machine them to a final dimension. Oh yes, Amweld will machine them for you.



They are rings made by a company with experience in design. We can help you select a mill-rolled or extruded shape that is even closer to the finished ring dimension. This can give you additional savings.

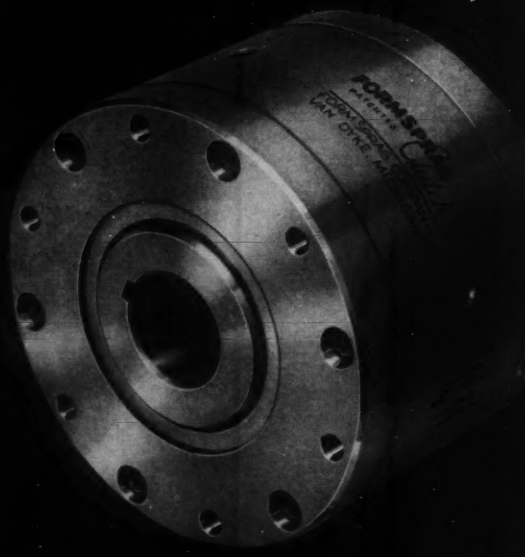
Yes, Amweld flash-welded rings can give you extra profit from savings on material and machining time. Amweld rings can be made of most weldable ferrous or non-ferrous metals in sizes from 4 to 96 inches.

AMERICAN WELDING

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD, WARREN, OHIO

NEW: Formsprag Sealed Clutch Series

LOCKS LUBRICANT IN



SEALS DIRT OUT

Now available—the new series "B" and "C" Formsprag Ball Bearing Sealed Clutches – designed for backstopping, indexing and low speed over-running where inner race over-runs.

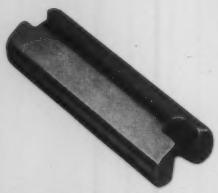
The "B" is intended for over-running applications where both races rotate during some portion of the operating cycle. The "C" series should be selected if the application is one of indexing or if the outer race is to be fixed, as in a backstopping application.

Available in bore diameters ranging from 2¼" to 5½", these new clutches have torque capacities from 1875 to 11,600 ft.-lbs. So you get unusually compact power transmission, the ultimate in accuracy, and exceptionally long service life. What's more Formsprag clutches may be reconditioned twice before obsolescence at a fraction of the cost of a new clutch.

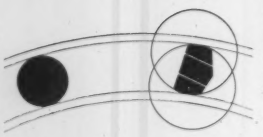
CHECK THESE CAPACITIES

Model No.	Maximum over-running speed RPM	Torque capacity lb.-ft.	Maximum bore diameter
FSB-700	900	1,875	2¼"
FSB & FSC-750	600	3,160	2¾"
FSB & FSC-800	600	4,200	3½"
FSB & FSC-900	600	6,000	4½"
FSB & FSC-1000	500	11,600	5½"

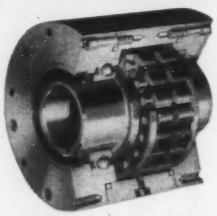
WHY IT PAYS TO DESIGN "THE FORMSPRAG PRINCIPLE" INTO YOUR PRODUCT



Sprags are an advanced design of precision wedges made of hardened alloy steel. Utilized in a clutch, they increase the efficiency and prolong the life of all equipment using an over-running clutch or ratchet.



The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space—therefore, of increased torque capacity.



Designed for backstopping, indexing and low speed over-running service where inner race over-runs. Formsprag will make selection of either "B" or "C" series when application data sheet accompanies order.

MORE INFORMATION?

Should you require details on these Formsprag small clutches as well as the complete line, write today for this new 26-page catalog.

Over-Running, Indexing and Backstopping Clutches for aircraft, automotive and various industrial applications

FORMSPRAG COMPANY

23603 HOOVER ROAD, VAN DYKE (DETROIT), MICH.

World's largest exclusive manufacturer of over-running clutches. Distributors in principal cities.

A7-12C

Circle 562 on Page 19

panel area 25/32 in. long x 3/8 in. wide. Solder-lug terminals, located on rear of switch, handle wires to No. 18. Electrical ratings are 2½

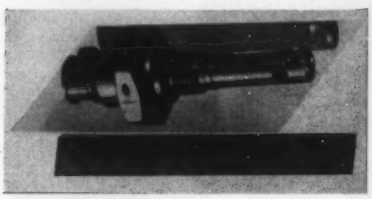
amp 30 v dc, inductive; 4 amp 30 v dc, resistive; 5 amp 125/250 v ac. **Unimax Switch,** Div., W. L. Maxson Corp., Ives Rd., Wallingford, Conn.

Circle 751 on Page 19

Temperature Transducer

withstands high vibration and pressure

New temperature transducer is a precision resistance - thermometer type utilizing deposited platinum film techniques. It has high speed of response, and withstands extremes of vibration and pressure. Base resistance is up to 10,000 ohms, with temperature ranges



from −370 to 500 F. Sensing element is ⅛ in. in diam and 0.030 in. thick. Instrument is for use in missiles, automation, and instrumentation applications. **Nacimco Co.,** National City, Calif.

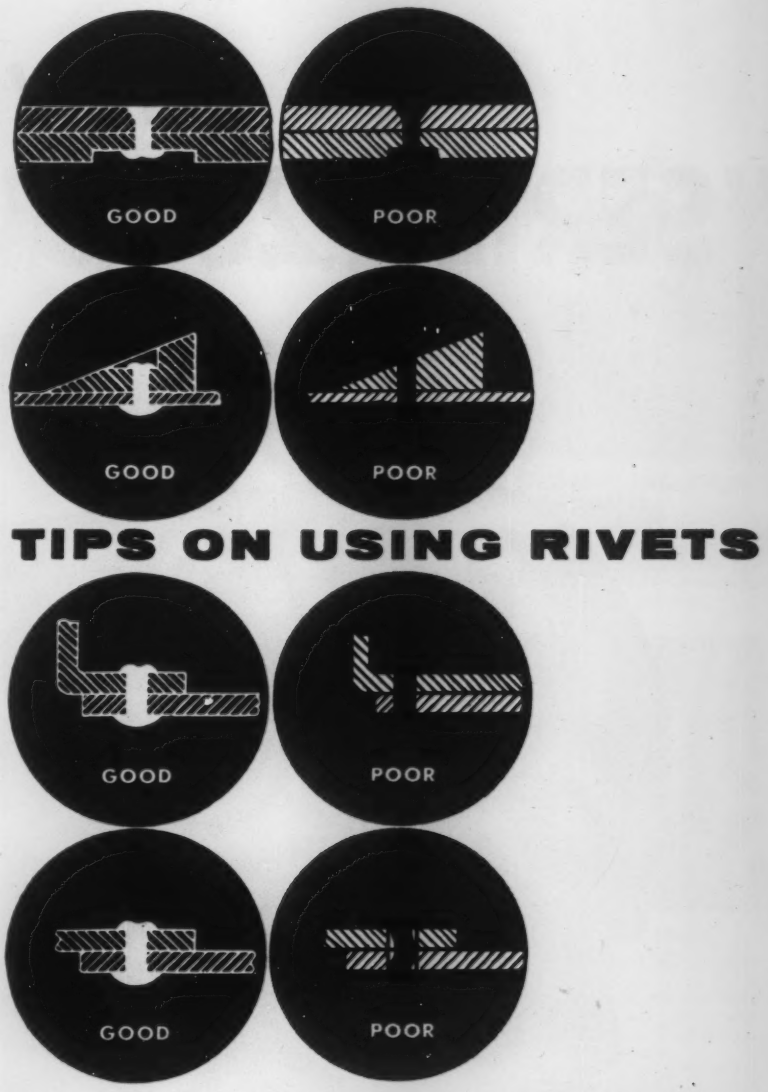
Circle 752 on Page 19

Rotary Pump

operates at pressures to 500 psi

Heavy-duty rotary pump, available in sizes 1 through 4, is applicable to oil-burner service, high-pressure coolant service, small hydraulic systems, hydraulic lifts, and other applications requiring a heavy-duty

(*Please turn to Page* 262)



A short design course guaranteed to save a lot of grief later on!

You could memorize these and thousands more design tips on the best use of rivets—but don't! Much simpler to call on Milford for the right answers to all your riveting design and application problems. Full-tubular, semi-tubular, split, cutlery, decorative—Milford makes them all from any metal that can be cold-formed, then adds a wide variety of platings and finishes.

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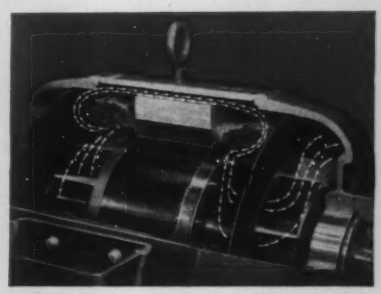
Circle 563 on Page 19

NEW ROBBINS "SERIES 254U" RE-RATED FIVE BIG

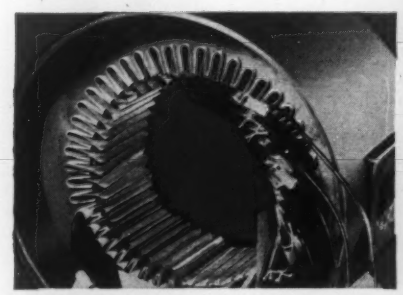
FULL HEIGHT END HEAD PROTECTION
One piece shrouded end heads give full height protection against moisture and falling objects. Internal baffles complete splash-proof construction.

& MYERS MOTORS offer you... ADVANTAGES!



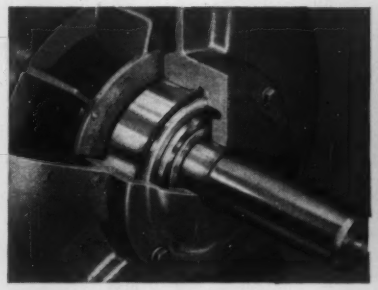
"STRAIGHT THROUGH" DUAL-SWEEP VENTILATION ELIMINATES "HOT SPOTS"

Tandem fans, one pushing and the other pulling, produce washing action around and over field coil ends, insure lower internal temperatures and longer dependable operation.



MYLAR* INSULATION INCREASES MOTOR LIFE. Mylar*, laminated to rag paper insures positive insulation and assures virtually permanent protection because of its excellent dielectric qualities. In addition, the rag paper backing provides a cushioning effect for added resistance to abrasions and punctures.

*DuPont registered trademark.

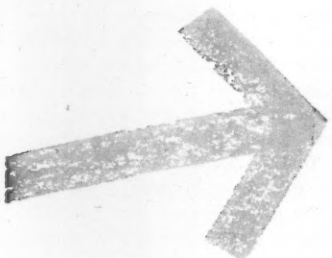


BEARINGS EASILY INSPECTED

Removable cover plate at each end of head permits easy bearing inspection without dismantling motor. Bearings run in double-width races, thus have extra-large reservoirs containing grease selected to resist dust, temperature, humidity and high operating speeds.

PERMANENTLY NUMBERED LEADS SIMPLIFY INSTALLATION AND MAINTENANCE

Proper lead identification is assured even after years of exposure. Numbers are permanently impregnated into the sub-surface of the insulation . . . can't wear off or deteriorate.



THESE five big advantages make R&M's "Series 254U" re-rated motors your best buy for applications requiring dependable, full-time performance. They can be installed in any environment, outdoors without a cover or in damp and corrosive atmospheres. Moisture, rust or corrosion can't affect their operation, and they take rugged duty in stride! Every R&M motor is electrically and mechanically designed to withstand the most severe operating conditions. Careful quality control and precision manufacture insure top performance and dependability year after year. Write today, for R&M Bulletin 520MD on R&M's "Series 254U" re-rated motors!

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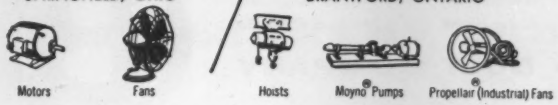

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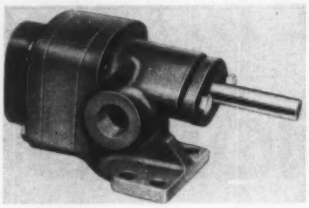
Division of Buffalo-Eclipse Corporation

NORTH TONAWANDA, N. Y.

New Parts

(*Continued from Page 259*)

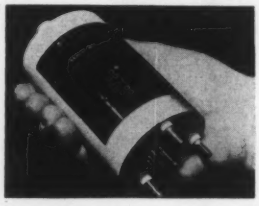


pump for continuous service at pressures to 500 psi in capacities to 25 gpm. Unit has suction and discharge openings from ½ to 1 in. NPT. Design features include nodular iron herringbone gears, four force-feed lubricated roller bearings, and single stuffing box available with packing or mechanical seal for minimum leakage. **Worthington Corp.,** Harrison, N. J.

Circle 753 on Page 19

Multi-Circuit Timers

meet military specifications



Line of time-delay relays and sequence program switches offers up to six load circuits in the repeat-cycle timer and up to five load circuits in the reset-cycle unit. Units meet varied requirements of sequence programming. Applications include guided missiles, fire controls, gun purge doors, flashers, radio, radar, and camera controls. Latitude in timing cycles ranges from seconds to hours. Motors in all timers operate on 115 v, 400 cycles. Load switches are single-pole, double-throw precision type. Units operate between −55 and 85 C to an altitude of 50,000 ft. Envelopes are hermetically sealed. Timers weigh from 16 to 24 oz. **Automatic Timing & Controls Inc.,** King of Prussia, Pa.

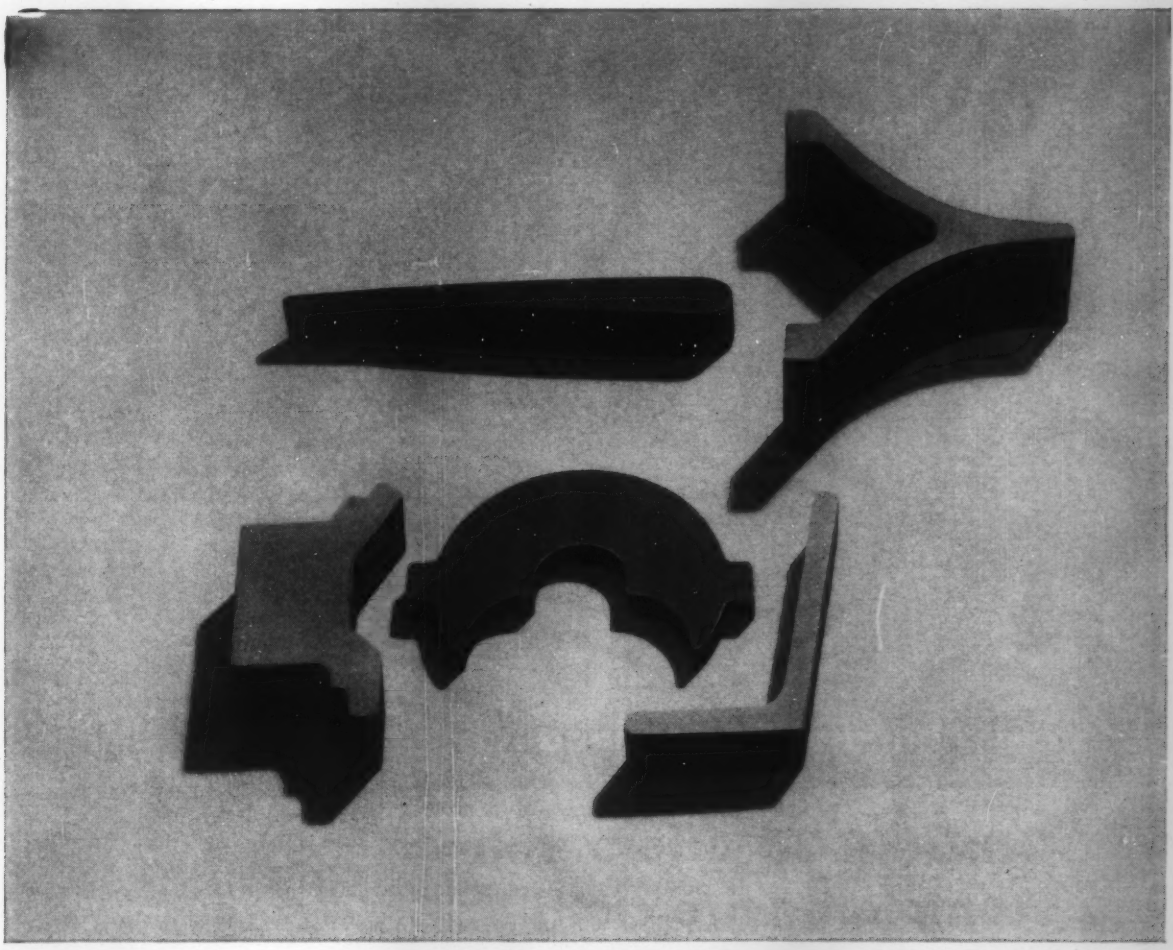
Circle 754 on Page 19

Magnetic Brake

has built-in damper

Model 1041 magnetic brake, designed for aircraft use, weighs 1.25 lb and is 4.1 in. long, 1.85 in. thick,

Circle 565 on Page 19



Intricate Allegheny Ludlum Steel Extrusions

cut material needs up to 60%, slash machining costs

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12-pages of design and engineering information on steel extrusions. Process and product explanation, material properties, design tips and limitations, tolerances, order instructions, etc.

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There's no doubt about extruded shapes saving money on materials and on machining. Non-ferrous applications in the last decade have proven it.

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If you're hogging out sections, paying for special mill rolls on small orders, or waiting for minimum rolling mill tonnages, Allegheny Ludlum Steel Extrusions are your answer. They will save you scrap loss, slash your machining costs, hold down your inventory requirements and cut delivery time. Charge for die design is low—under $200. Orders taken for as little as 40 pounds.

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Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.

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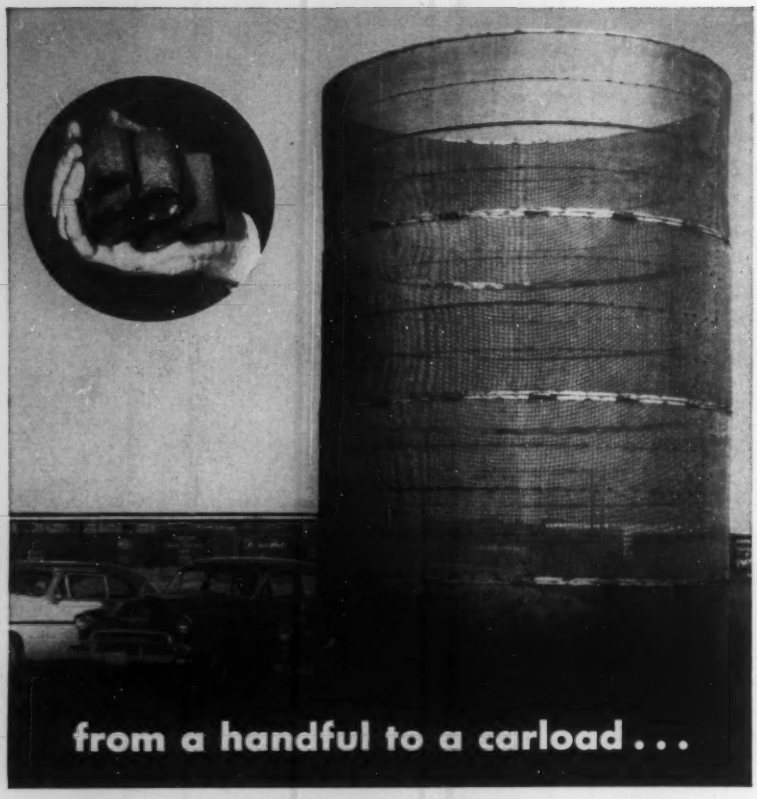
for all your special steel needs

Stainless and high-temperature, electrical and tool steels, magnetic materials, and sintered carbide

Circle 566 on Page 19



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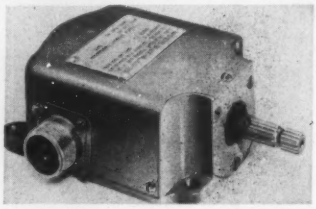
New Parts

and 3 in. wide. It is equipped with a built-in damper which operates on the eddy-current principle. When brake is energized, input shaft is unlocked and damper resists input forces in direct propor-



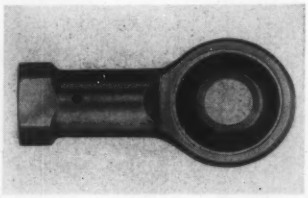
tion to input speeds, to control input forces and absorb force gradients. When brake is de-energized, input shaft is locked to resist torque up to 200 lb-in. **Lyndon Aircraft Inc.,** 140-55 Clifford St., Newark, N. J.

Circle 755 on Page 19

Rod-End Bearings

in ¼ to 1-in. bore sizes

Alinabal spherical rod-end bearings have self-lubricating sintered-metal balls and full spherical race of hardened steel, ground to match ball curvature. Construction is particularly suited for linkages with rotating or oscillating motion. Load is applied directly to center of ball and distributed over full race curvature, providing longer bearing cy-



cling life and maximum radial and axial thrust loads. Ball is available in sintered bronze or iron, oil impregnated and self-lubricated. Bore sizes are ¼ to 1 in. in male and female type. **Carter Engineering Co.,** Ferrysburg, Mich.

Circle 756 on Page 19

Industrial Triode

for oscillator applications

Type 7092 radiation-cooled, high-power industrial triode is designed for industrial oscillator applica-

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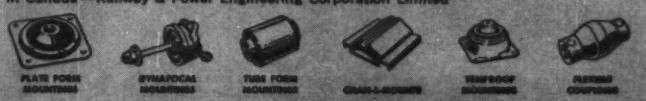

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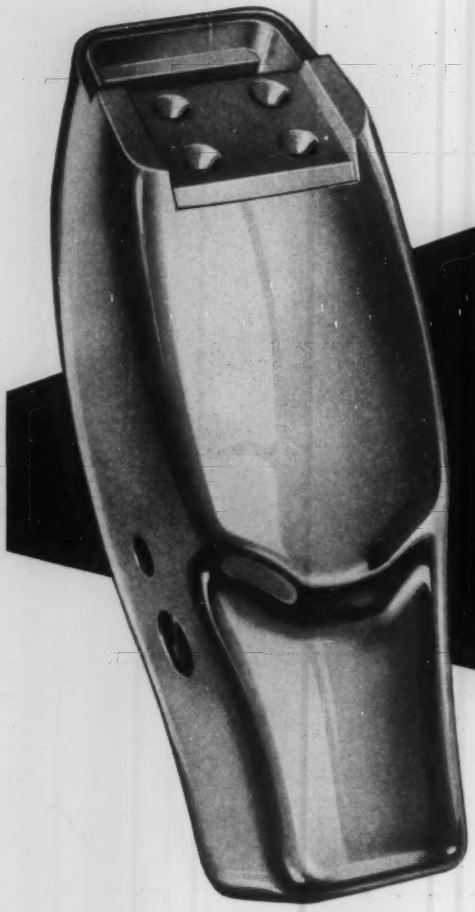

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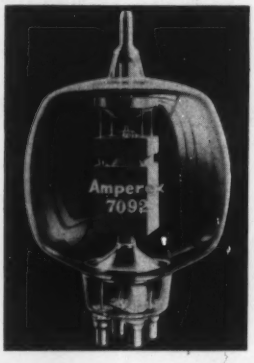


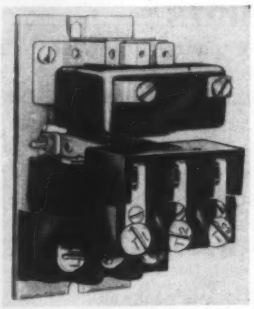
tions in ultrasonic, induction, or dielectric heating equipment. Heavy-duty anode withstands heavy overloads. Tube envelope is thick, hard glass for temperature resistance and ruggedness. When triode is used in continuous class C operation, 2 kw power into industrial loads can be obtained, and 3 kw in intermittent operation. Thoriated - tungsten filament is rated at 6.3 v, 32.5 amp. Industrial Tube Div., **Amperex Electronic Corp.**, 230 Duffy Ave., Hicksville, L. I., N. Y.

Circle 757 on Page 19

Magnetic Relay

for fractional and integral-horsepower motors

New 20-amp magnetic relay is suitable for all types of fractional and integral-horsepower motors used in commercial and industrial applications. Unit has silver



cadmium oxide contacts, and assures minimum contact bounce. It is available in two, three, and four-pole, and all standard voltages. **Arrow-Hart & Hegeman Electric Co.**, 103 Hawthorn St., Hartford 6, Conn.

Circle 758 on Page 19

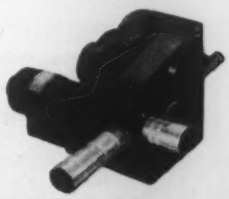
When it sings out, engineering mysteries unfold

The high-pitched whine of a high speed camera is bursting forth more and more often in modern engineering laboratories. For engineers have found that ultra-slow-motion movies make trouble shooting in fast-moving parts more a matter of intelligent visual analysis than of tedious cut-and-try experimentation or calculation. And that leaves them more time for design and development work.

The high speed camera we make is primarily for the practical engineer to use in helping solve his day-to-day problems. Its top speed is a reasonable 3200 pictures a second. That slows action 200 times when you project the 16mm film at normal speed, enough in the great majority of mechanical problems to see what's going on. You don't burn up more film than you need and the instrument is simple and rugged enough for a busy man to use without trouble.

The best way for you to evaluate the Kodak High Speed Camera in terms of your own needs is to send for a booklet that not only gives you the details but quite a few case histories on how it has been used in a variety of industries. You get the booklet by writing to *Graphic Reproduction Division,*

EASTMAN KODAK COMPANY
Rochester 4, N. Y.



the Kodak *HIGH SPEED* Camera

Kodak

Circle 570 on Page 19

PALNUT® LOCK NUTS and FASTENERS

REDUCE — PARTS — OPERATIONS — COSTS

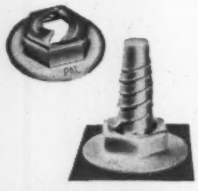
Spring-tempered steel PALNUT Lock Nuts and Fasteners cost less than other lock nuts and locking devices—less than plain nuts, in most cases. A single PALNUT replaces two, three, even four fastening parts according to application and type used, thus fewer parts to buy, stock and assemble. Simplified, high speed assembly is gained with PALNUT magnetic sockets, shanks and applicators which pick up, start and tighten in one operation. Self-locking spring grip keeps parts tight under vibration. Many types and sizes offer savings for products in every field.

REGULAR TYPE

Self-locking hex nuts securely fasten wide range of light assemblies. Require only 3 screw threads. Save weight. Also used on top of ordinary nut for vibration-proof fastening of assemblies.

WASHER TYPE

One-piece lock nut and flat washer replaces ordinary nut, lockwasher and flat washer. Many variations for mechanical and electrical assemblies. Available with bonded-in plastisol sealer.

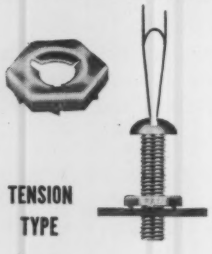


SELF-THREADERS

Form deep, clean threads on unthreaded studs, rivets and rods while tightening. Save threading costs. Provide strong, vibration-proof assemblies. Fast assembly with standard tools. Remove and re-use on same studs.

ACORN TYPE

Pleasing dome shape covers rough screw ends, dresses up products, keeps parts tight. Also semi-acorn type with prevailing torque anywhere on threads. Very low cost.



TENSION TYPE

Simplifies adjusting screw assemblies. Nut is tightened once, never touched again. Use only screwdriver to adjust screw. Positive grip.

PUSHNUTS® for unthreaded studs, rods and rivets.

Simply push on, they lock with powerful grip. Save threading, notching, cotter pins.

WING TYPE

Lock securely when finger tightened, stay tight in service, easily removed when finger released. Cost less than ordinary wing nuts.

Write for literature and free samples of any type PALNUT Lock Nut, stating application and size. Consult our fastening engineers on any assembly problem.

THE PALNUT COMPANY

75 Glen Road, Mountainside, N. J.

Subsidiary of United-Carr Fastener Corp.

Canada: P. L. Robertson Mfg. Co., Inc., Milton, Ont.

PALNUT® LOCK NUTS FASTENERS PAL®

Quick, secure fastening at low cost

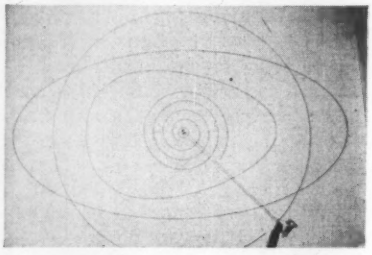
Circle 571 on Page 19

ENGINEERING DEPARTMENT
EQUIPMENT

Drafting Instrument

draws ellipses, circles, spirals, and curves

Ellipsene drafting instrument draws ellipses, circles, ovoids, spirals, and curves in sizes from ½ in. to over 20 ft. It can be used as an ordinary compass or as a beam compass. Instrument also



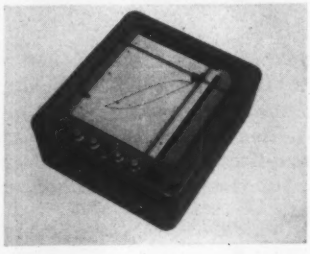
produces the Spiral of Archimedes. Pencil, ink, or ball pen can be used to draw, and a metal scriber can be used for layout on metal or cardboard. **Debs Instrument & Tool Co.**, 1750 Troutman St., Ridgewood 37, N. Y.

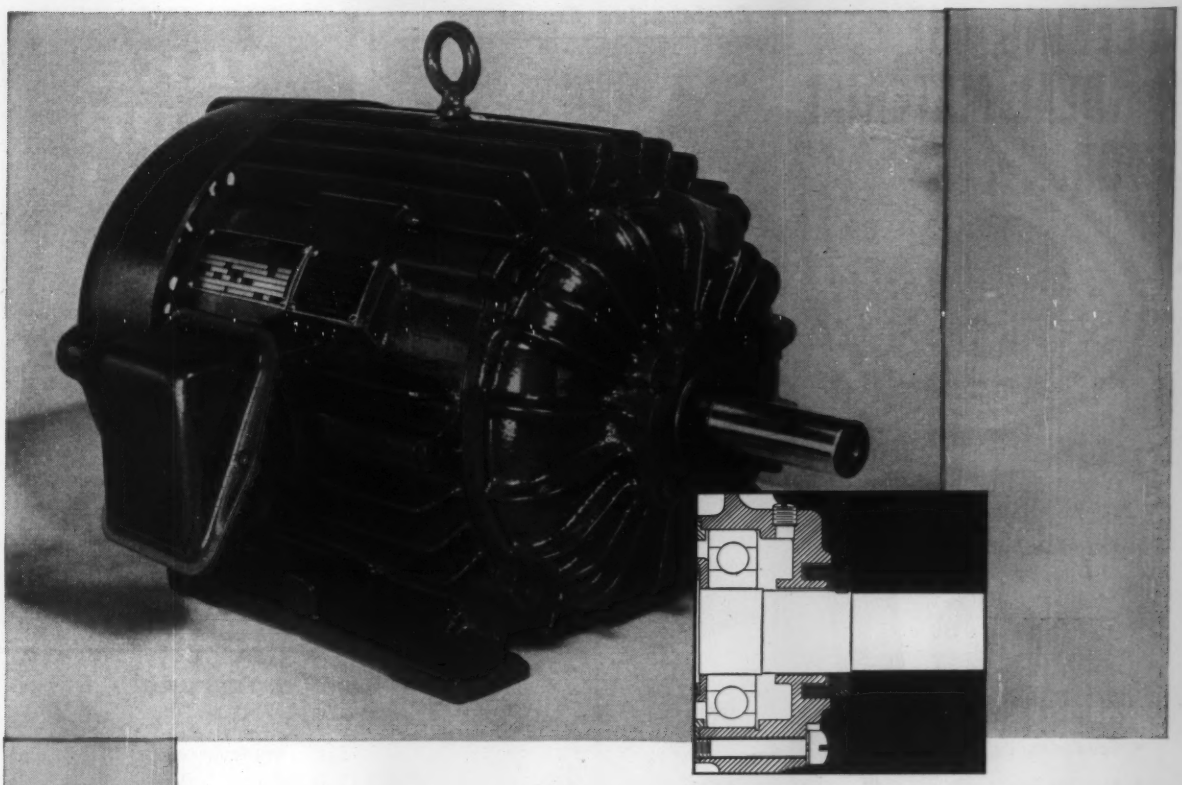
Circle 759 on Page 19

X-Y Plotter

has input sensitivity to 1 mv per in.

ER-90 plotter incorporates flat-bed construction for full-chart visibility, and slip-on pen for plotting on standard 8½ x 11-in. paper. Input sensitivity is as high as 1 mv per in. Chopper-stabilized amplifiers, standard three-turn rebalance potentiometers in the null-seeking servo system, and simplified cord





Securely sealed for low maintenance —

Century TOTALLY ENCLOSED FAN COOLED MOTORS

When motor maintenance goes down, production goes up. Century TEFC Motor *protects itself* from dust, grit, chemical fumes, moisture. Shaft openings at each end are labyrinth-sealed, and there is a precision clearance between metal seal and bearing bracket.

Outside, a hose or whisk broom quickly cleans it. External fan forces jets of cooling air across the frame. Inside, vital motor parts are completely sealed off from injurious atmosphere. Factory lubrication of bearings is adequate for several years' service under normal conditions; however, whenever required bearings may be relubricated through grease plugs.

For full facts on your specific application, call the Century District Office or Authorized Distributor nearest you.

CENTURY . . . building TEFC Motors for 25 years

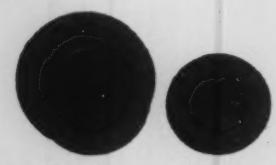
CE-66R

Performance-Rated©
MOTORS
1/20 to 400 H.P.

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

SEEKING THE IDEAL MATERIAL FOR...



• Molds for powder metallurgy?

• Sintering boats?

• Crucibles, jigs, plates?

• Similar hot applications?

HERE'S YOUR ANSWER

Speer carbon and graphite parts are not wetted by molten metals. They hold their shape with no warping, regardless of temperature. They have high heat transfer and will not break down under severe thermal shocks...will not crack or split... are chemically inert.

Easily machined or fabricated, Speer carbon and graphite parts can be provided in almost any size and shape to your *exact* dimensional tolerances. If you have a design problem involving high temperatures, examine the advantages—and economies of Speer Carbon. Speer's knowledge and experience is yours for the asking—mail the coupon today for further details.

SPEER Carbon Co. St. Marys, Pa.

Please send information on carbon for use in

_____

_____

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Circle 573 on Page 19

Engineering Equipment

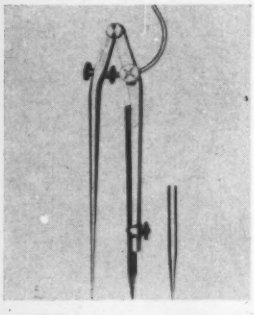
drive system insure reliable operation. The two axes are electrically independent. Recorder has a limit of errors better than 0.75 per cent, and repeatability better than 0.05 per cent. **Mandrel Industrial Instruments,** Div., Mandrel Industries Inc., 5134 Glenmont Drive, Houston, Tex.

Circle 760 on Page 19

Heavy-Duty Divider

holds long pencil or steel scribing point

This 9-in. heavy-duty divider features fine adjustment, rigid construction, and firmly locked settings. Steel scribing point is interchangeable with a standard long pencil. Unit eliminates wandering



when scribing coarse-grained wood or rough-surfaced metal. Quadrant, projecting through the legs and locked by a knurled clamp screw, eliminates side deflections. Check nut, spring, and quadrant-adjusting nut permit fine adjustments for close measurements. **L. S. Starrett Co.,** Athol, Mass.

Circle 761 on Page 19

Servo-System Analyzer

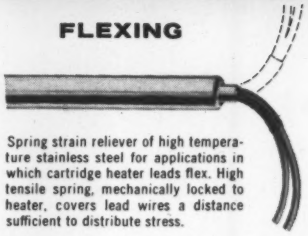
measures gain, phase shifts of servomechanisms

Model F Servoscope is a sweep generator, multiple-signal generator, and phase-angle indicator. Dials, switches, and information display on the front of the unit have been engineered to reduce fatigue and increase accuracy. Unit provides a direct method for measuring gain and phase shifts of any component or system in subsonic frequency ranges. Phase lead or lag is shown within 1 deg. Instrument provides sine, modu-

TAKE YOUR PICK!

Special Chromalox features solve 3 spot heating problems

FLEXING



Spring strain reliever of high temperature stainless steel for applications in which cartridge heater leads flex. High tensile spring, mechanically locked to heater, covers lead wires a distance sufficient to distribute stress.

MOISTURE

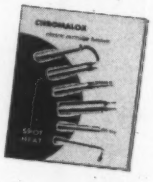
Moisture-resistant flexible brass conduit protects lead wires of cartridge heaters operating in presence of steam, water, oil and vapors. Also offers added protection from flexing, vibration and mechanical damage.

ABRASION

Flexible brass conduit protects cartridge heater lead wires against abrasion from other moving parts and from accidental mechanical damage. Safety factor where lead wires are exposed to machine operator.

FREE BULLETIN!

CHROMALOX ELECTRIC CARTRIDGE HEATERS



Get the full story. Call your Chromalox Representative or write today for Bulletin 850.

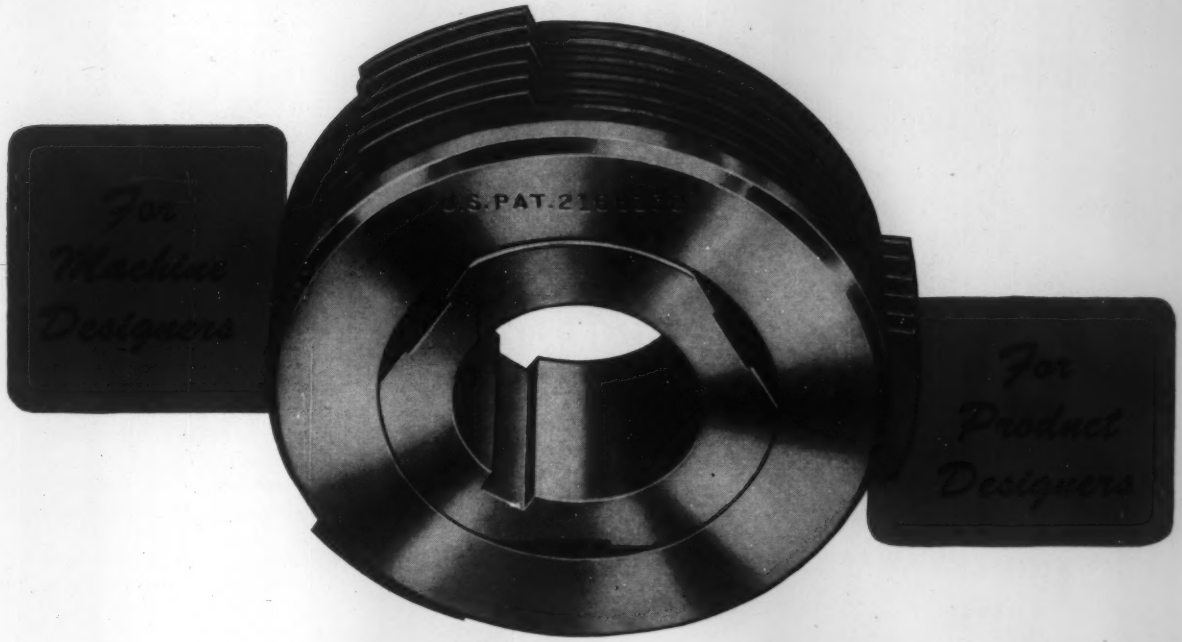
C-2101

Edwin L. Wiegand Company

7575 Thomas Boulevard • Pittsburgh 8, Pa.

CHROMALOX

Circle 574 on Page 19



MAXITORQ "DISC-PAC"

A COMPACT UNIT FOR BUILDING YOUR OWN CLUTCH

Due to a growing demand for Maxitorq Floating Discs, the MAXITORQ DISC-PAC has been made available as a self-contained unit independent of the actuator.

Patented Maxitorq Separator Springs that prevent drag, abrasion, and consequent heating in neutral . . . and the Maxitorq Locking Plate which locks all discs onto body . . . give you the outstanding features that are so highly favored by machine and product designers.

Thus you may build your own clutch or brake from our standard stock Maxitorq parts. The Disc-Pac keys to your shaft and is easily replaced. Units are available in 8-disc diameters from 2" to 8"; ¼ to 15 h.p. at 100 r.p.m. . . . with 3 lugs on the smallest size, 8 lugs on the 3 h.p., and 12 lugs on the 5, 10 and 15 h.p. capacities.

The Disc-Pac fits Maxitorq standard Driving Rings in the event that you want to use them. As with the Maxitorq Clutch, all assembly, take-apart and adjustments are manual . . . no tools required. For further information, write Dept. MD-12.

THE CARLYLE JOHNSON MACHINE COMPANY

Manchester, Connecticut

8CJ57

THERE MUST BE AN EASIER WAY

—AND THERE IS WITH . . .

MIDLAND

WELDING NUTS

The Midland Steel Products Company is constantly developing new, progressive ideas to improve the efficiency of its fine products. It pioneered the *Midland Welding Nut,* for example, and so successful was this application in its own shops that this labor-saving device has been made available to others.

If you are a manufacturer of metal parts or products and have fastening, fabricating or assembling problems, you may find Midland Welding Nuts just the solution you've been looking for. The Nuts are easily welded into position for the lifetime of the product. You can be assured of correct fit, even in the most awkward, hard-to-reach places. Bolts turn easily into the applied nuts. Thus, heretofore two-man operations can be handled by one man in most instances. Weld-nut equipped parts will be preferred by your customers for they will find them cost-saving and trouble-free, cutting down assembly time. Too, you can be sure that your parts will be properly assembled without the risk of rattles.

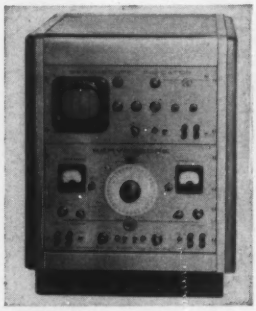
A few minutes' time in checking the assembly problems of your customers will be profitable to you. Midland Welding Nuts are low in cost, can give you a definite advantage over competition. This practical application is recognized internationally and endorsed by many designers of the finest products.

The MIDLAND STEEL PRODUCTS COMPANY

6660 Mt. Elliott Avenue • Detroit 11, Michigan
Export Department: 38 Pearl St., New York, N. Y.
Automobile and Truck Frames • Air and Vacuum Power Brakes
Air and Electro-Pneumatic Door Controls

Circle 576 on Page 19

Engineering Equipment



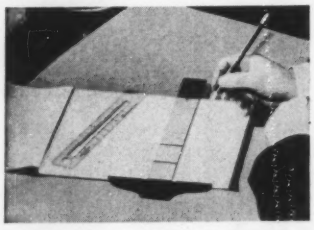
lated-sine, and square-wave signals, as well as linear sweep, on four ranges from 0.005 to 100 cps. Applications include automatic flight-control design, testing computer response, checking vibration, testing frequency response of electrohydraulic systems, and simulating rate gyro. **Servo Corp. of America,** 20-20 Jericho Turnpike, New Hyde Park, N. Y.

Circle 762 on Page 19

T-Square

can be used without a drawing board

This T-square is usable directly aganist the edge of a letter-size pad of paper. It permits the making of small drawings, sketches,



and plans without the use of a drawing board. T-square can be carried in a brief case. **Dolgorukov Mfg. Co.,** 407 Fisher Bldg., Detroit 2, Mich.

Circle 763 on Page 19

Pressure Transducer

measures pressures to 15,000 psi

Model PT32 high-pressure pickup is well suited for use where large pressures must be measured or recorded with a minimum alteration of the pressure chamber. Overall accuracy is within 1 per cent of full scale. Unit operates under

Circle 577 on Page 19→

Formica helps solve rocket thermal insulation problems

New Formica laminated plastic thermo-insulator provides protection from hot launching gases

In cooperation with Rocket Fuels Division, Phillips Petroleum Company, Formica application engineering applied Grade FF-34 (modified) with the precise characteristics for protection against hot gases.

This Formica fabricated liner protects the steel blast tube through a time cycle of intense heat in a new target drone.

This solution called for three of the Formica-4 services that assure the right laminated plastic for every requirement.

1. Application engineering to select the right grade
2. Research to adapt it to this particular application
3. Fabricating to produce a complete component ready for assembly. A fourth—Customer Stock Service—provides a ready supply of sheets and rods for prompt shipment.

This unique laminated plastics service can be of assistance to you in your own product design problems. For complete information, send for free Formica-4 bulletin 584. Formica Corporation, a subsidiary of American Cyanamid, 4514-7 Spring Grove Ave., Cincinnati 32, Ohio.

Save your engineers' time . . . use Formica-4, the complete laminated plastics service

FORMICA

CYANAMID

1. Application Engineering 2. Research 3. Fabricating 4. Customer Stock Service

FI-1586

PACKAGED *Oil-Free* COMPRESSED AIR

MOTOR
Ball bearings permanently grease packed—no re-oiling.

PORTABLE
Compact, light in weight, insulated handle.

INTEGRATED AFTERCOOLER, PULSATION CHAMBER, MOISTURE SEPARATOR
Provides cooler, drier air at smooth, uniform pressure.

AUTOMOTIVE TYPE FAN
Assures low temperature operation for higher efficiency, longer life.

SAFETY VALVE
(Not visible)
Provides constant bleed-off at maximum pressure. Also acts as automatic moisture drain.

GRAPHITE PISTON RINGS AND SKIRTS
Special composition needs no lubrication. Self-sealing piston ring joint reduces blow-by.

DRY VALVE CONSTRUCTION
Positive-sealing without oil. Self-cleaning—no rubbing parts.

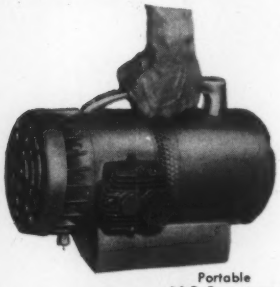
AIR WHERE YOU WANT IT... COMPLETELY OIL-FREE... COOLER... DRIER!
Expensive lubrication maintenance completely eliminated!

Where *clean* compressed air is essential, the B&G Oil-less Compressor provides the answer in a complete line of portable, tank-mounted and tankless models.

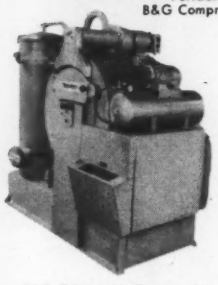
There is no oil required in this new design unit! Motor and compressor are permanently grease packed... graphite piston rings and skirts operate for years without destroying the mirror-finish of the cylinder walls. Since the cylinders are not lubricated, oil-free air is delivered at all times without need for an oil separator.

B&G Compressors are really *smooth!* Modern design large bore, short stroke, horizontally opposed pistons provide better balance and vibrationless operation. Compactness and light weight adapt them ideally to either portable or built-in applications. In every detail these units are designed to deliver *maximum air per horse power!*

For complete information on B&G Oil-less Compressors and Vacuum Pumps, send for Catalog GO-1156.



Portable B&G Compressor



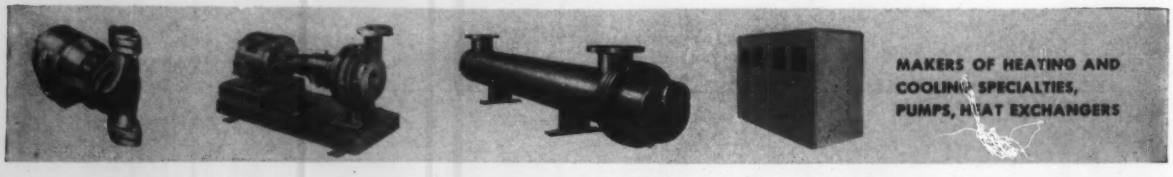
B&G Oil-less Air Compressor as integral part of dry cleaning machine

Oil-less AIR COMPRESSORS

BELL & GOSSETT COMPANY

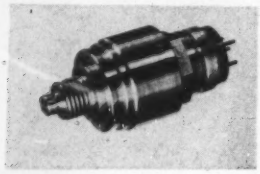
Dept. FB-67 Morton Grove, Illinois

Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Dr., Toronto 16, Ont.



Circle 578 on Page 19

temperatures from −65 to 350 F. Natural frequency is better than 25,000 cps. Transducer is avail-



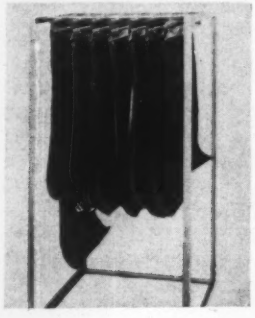
able in pressure ranges from 0-7000 to 0-15,000. **Dynamic Instrument Co.,** 28 Carleton St., Cambridge, Mass.

Circle 764 on Page 19

Vertical File

holds 700 plans to 24 x 36-in. size

Glider 700 all-steel, blueprint rack accommodates 700 plans in sizes up to 24 x 36 in. Seven retainers, available in 18 and 24-in. lengths, hold 100 prints each. They incorporate a thumb-screw clamp design that pressures prints in filing position, securing them firmly without crimping. Individual in-



sertions and removals can be made without disturbing other prints. **Momar Industries,** 4323 W. 32nd St., Chicago 23, Ill.

Circle 765 on Page 19

DC Power Supply

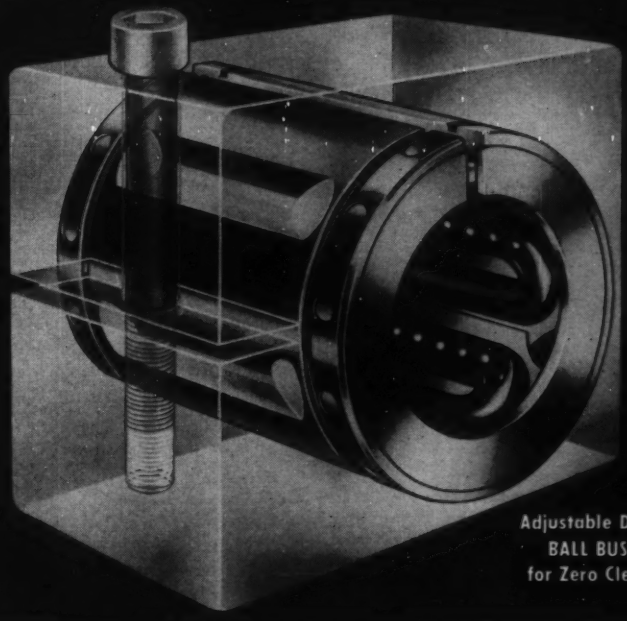
has voltage regulation to ±1 per cent

Model TM25 tubeless laboratory-type regulated dc power supply has a continuous-duty rating of 0-150 v dc at 2 amp. Voltage regulation is held to ±1 per cent and ripple is less than 0.03 per cent of average dc at maximum output. Unit is available for panel mount-

Circle 579 on Page 19→

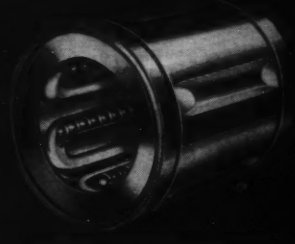
NOW! *Adjustable Diameter and Open* THOMSON

BALL BUSHINGS

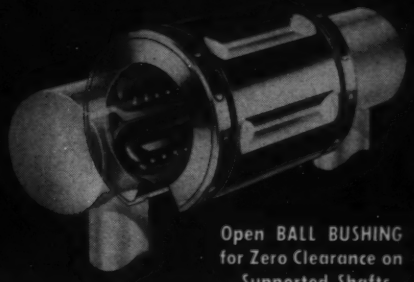


Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**



Precision Series "A" and Low Cost Series "B" BALL BUSHING



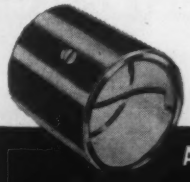
Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION • ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

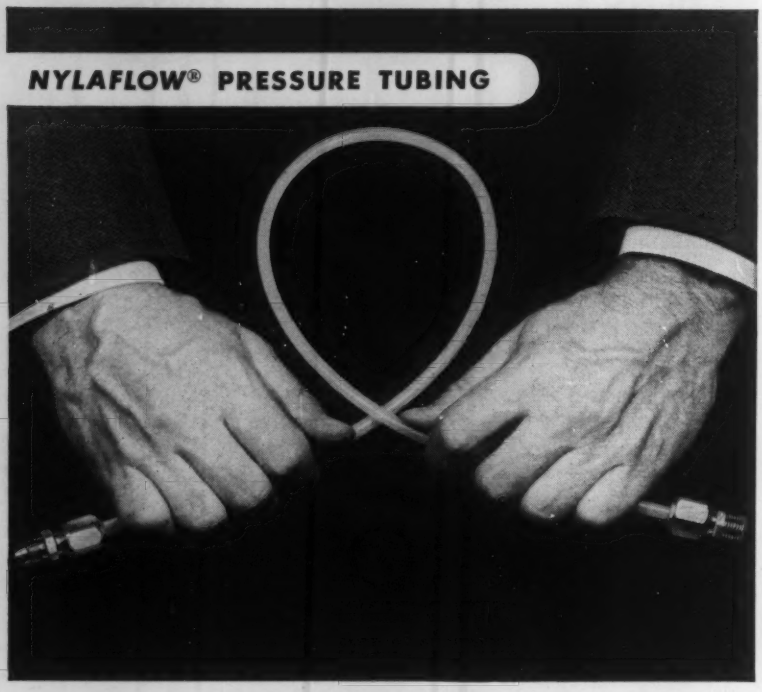
The various types cover a shaft diameter range of ¼" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.



THOMSON INDUSTRIES, Inc.
Dept. E, MANHASSET, NEW YORK

Circle 516 on page 19

Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting



NYLAFLOW® gives you high strength, long flex life, light weight

NO OTHER tubing offers the same unusual combination of physical properties with ease of installation . . . to provide lower costs, long tubing life.

Nylaflow is a tough, flexible polyamide tubing being used successfully in many industries for air lines, grease and oil lines, low pressure hydraulic lines, beverage lines and other applications.

These are *Nylaflow's* unique characteristics:

- High burst pressure at low cost
- Extremely long flex life
- Tough—wear and crush resistant
- Hornlike, can be used with standard fittings
- Easily bent for installation—can be held with clips or permanently pre-bent with heat
- Serves over wide temperature range
- Resistant to solvents, oils, alkalis, hydraulic fluids
- Odorless, tasteless, non-corrosive, non-toxic, fungus resistant

The design and performance capabilities of Nylaflow are outlined in a new bulletin available from The Polymer Corporation of Pa., Reading, Pa. Write for your copy today.

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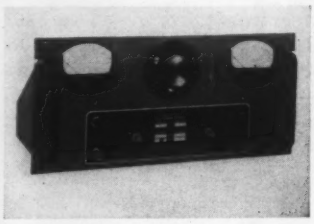
POLYPENCO nylon, POLYPENCO Teflon†, NYLAFLOW® & NYLATRON® GS. †Du Pont Trademark

Circle 580 on Page 19

Engineering Equipment

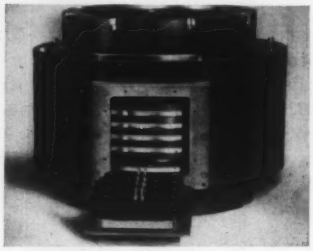


ing or in a cabinet for bench use. Controls include a power switch, pilot light, indicating-type line and load fuses, voltmeter, ammeter, and five-way insulated binding posts. **Opad Electric Co.**, 69 Murray St., New York 7, N. Y.

Circle 766 on Page 19

Slip-Ring Assembly

has strain-gage applications



Totally sealed slip-ring assembly, originally made for checking strain-gage readings on ships, can be adapted for other instrumentation circuits, thermocouple applications, and power circuits. Large size rings and brushes give high current capacity. The drum-type assembly has ID of 6¾ in. **Superior Carbon Products Inc.**, 9115 George Ave., Cleveland 5, Ohio.

Circle 767 on Page 19

Magnetic Tape Recorder

for slow-speed operation

Model TT-100 multichannel magnetic tape recorder operates in —20 to 165 F temperatures. Designed for slow-speed operation, unit provides up to three record channels at speeds from 0.05 to 1⅞ ips using ¼-in. tape on 5-in. NARTB reels. Instrument weighs 5 lb and occupies a space 12 x 6 x 4 in. Power requirement is 6 v dc, ranging from 100 to 300 ma. **Precision Mechanism Co.**, 922 Terminal Way, San Carlos, Calif.

Circle 768 on Page 19

WHICH of these Actuation Problems are YOURS?

☐ POWER CONSUMPTION ☐ SPACE/WEIGHT ☐ PRECISION

☐ TEMPERATURE ☐ LUBRICATION ☐ DEPENDABILITY

SAGINAW b/b SCREWS will help you solve them!

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1. Vital Power Savings. Permit much smaller motors with far less drain on electrical system, simpler circuitry.

2. Space/Weight Savings. Screws themselves are smaller, lighter; permit smaller motors and gear boxes; eliminate auxiliary equipment required by hydraulics.

3. Precise Positioning. Machine-ground type will position components far more precisely than hydraulics or pneumatics; tolerances on position are held within .0006 in./ft. of travel.

4. Temperature Tolerance. Normal operating range from −75° to +275° F.; in selected materials, will function efficiently at temperatures as high as +900° F.

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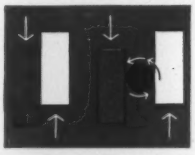
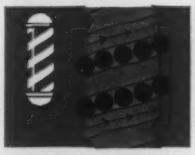
6. Fail-Safe Performance. Far less vulnerable than hydraulics; Gothic-arch grooves, yoke deflectors and multiple circuits provide added assurance against failure.

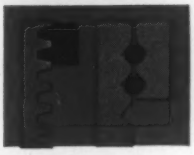
Here's why they're 90% efficient, save 4/5 on torque:



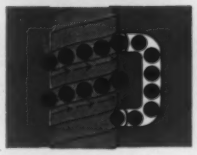
Let's start at the beginning, with the familiar principle that there's far less friction in *rolling* than in *sliding*. By applying this principle,



Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.

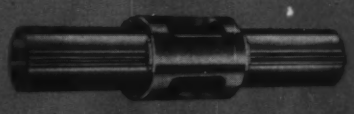


the *Saginaw ball/bearing Screw* radically increases the efficiency of rotary-to-linear motion (and vice versa). Instead of *sliding*, mating surfaces *glide* on rolling steel balls.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

SAGINAW b/b SPLINE



This revolutionary new kind of spline utilizes the same basic principle pioneered by Saginaw in the ball bearing screw.

It permits new engineering designs never before practical—literally lets you achieve the "impossible"! In any application where column length must change under torque load, the Saginaw b/b Spline offers greatly decreased friction, less wear, longer life, more dependable operation. It can be fitted with integral gears, clutch dogs, bearing and sprocket seats or a wide choice of other attachments for use with electric, hydraulic or pneumatic units. To convert push-pull to rotary motion, helical types are available with very high loads, ranging from 20:1 to 100:1.

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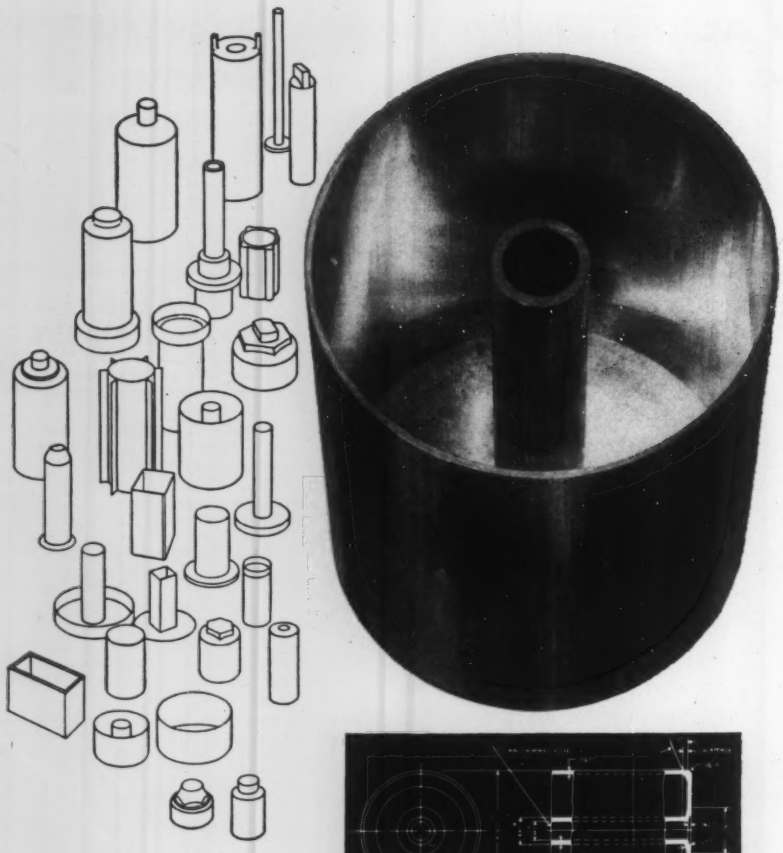

made in one piece–in one stroke as an **ALCOA IMPACT**

Faced with the problem of designing this center-tube impact as a one-piece part, a designer who is not familiar with Alcoa® Impacts would throw up his hands. Then he would break out the slide rule to start figuring costs on welding the center tube to the base. After that, he'd have to puzzle out an inexpensive way to join the base to the side wall. The fact is, he never would figure out a way to do it economically.

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To guide your thinking, check the handy rules of thumb below. Any part that is a closed-end tubular part, or cup-shaped, should be considered as an Alcoa Impact. In one shot, we can make round, oval, square or special shapes. Ribs, splines, flutes or other functional or decorative patterns can be incorporated on the inside or outside. Let your imagination go to work; we're anxious to go to work for you.

To get your imagination started, send for Alcoa's design manual, *Alcoa Impacts—Metal in Motion*. You'll find it loaded with design tips and ideas that have saved other designers a lot of money. For on-the-spot assistance, call your nearest Alcoa sales office. It's listed under "Aluminum" in the Yellow Pages of your telephone directory. An Alcoa sales engineer will put his solid technical know-how at your disposal. Aluminum Company of America, 1991-M Alcoa Building, Pittsburgh 19, Pa.

Some Impact Rules of Thumb—Check your problems against this list:

1. Parts requiring hollow sections—either tube or cup-shaped with one end closed.
2. Parts with walls or surfaces requiring zero draft.
3. Parts requiring lengths up to eight or ten times the diameter.
4. Parts requiring the strength of forgings.
5. Parts requiring tolerances down to ± 0.005".
6. Parts requiring ribs, bosses or fins as integral parts.
7. Parts requiring low unit cost in mass production. (Often the savings in machining, fabrication and assembly made by impacts amortize tooling in relatively short runs.)

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Circle 582 on Page 19

Professional Viewpoints

. . . from engineer to supervisor . . .

To the Editor:

The article "The Transition from Engineer to Supervisor" (MACHINE DESIGN, October 31, 1957) was very timely for my current purposes as an engineering supervisor. Because the general topic was very fresh in my mind, the content of the article was keenly appreciated.

It was encouraging to me to read so much which concurred with what I have been learning and practicing in this field. On the other hand, there are certain differences in opinion which may prove interesting.

1. The point is made, relatively strongly, that the characteristics a man will have as a supervisor are very strongly dependent on what happens to him during the transition period. This is certainly a very critical time in a man's career. However, I like to think that patterns set at this time, while strong, are not really as unchangeable as the content of this article might lead a reader to believe.

Constant Coaching Essential

2. Under "Areas of Training" three areas of proficiency are outlined. A fourth area, one which overlaps the other three, is that of coaching. Much of the literature pertaining to the subject emphasizes that the essence of good administration and supervision lies in the ability of a supervisor to counsel and coach his subordinates. The consistent references to the training function in the remainder of the article shows that the author is well aware of this function, particularly during the transition stage. I suggest consideration of the importance of this function as a constant duty of supervision. Referring to Point 1 above, this training function is the means whereby habits established during transi-

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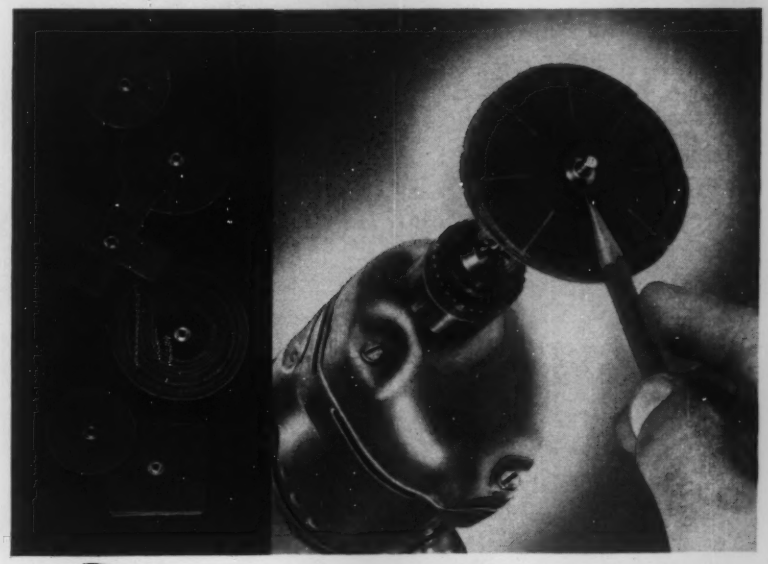

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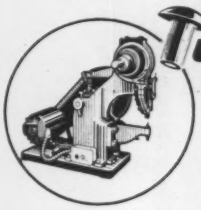

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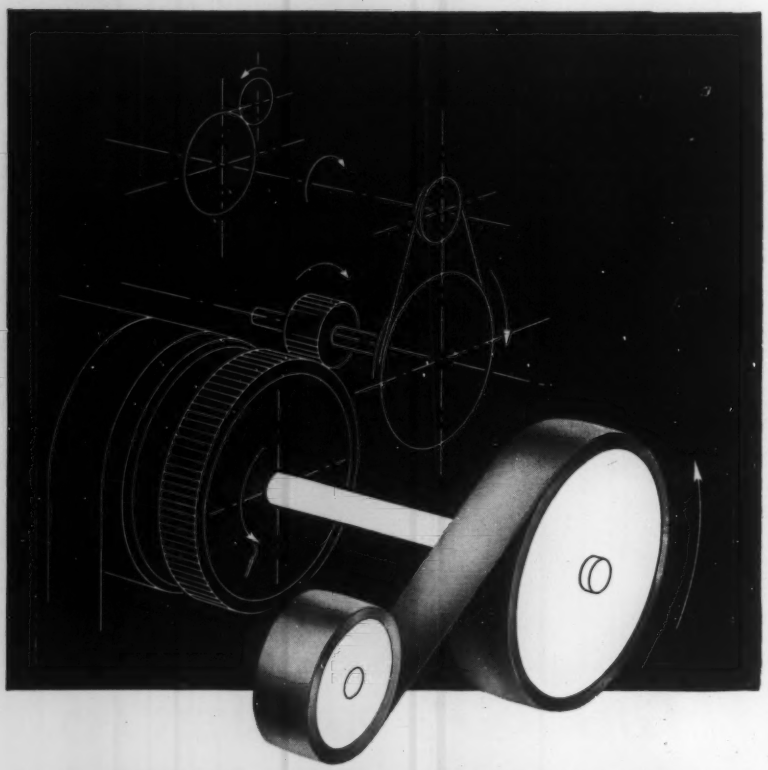

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tion from engineering to supervision can be modified and possibly sublimated.

3. The points on communications are excellent and well put, in my opinion.

4. Under "Transition to Leadership" reference is made to the fact that "Group Leadership" can be developed only if the characteristics or traits already exist in the individual. The article would have been more acceptable to me if the fact was recognized that these traits basically do exist in everyone, and that those who have the most difficult time becoming good leaders, i.e., in bringing these traits to fruition, may very often be the best leaders. The point here is that anyone who has had many problems in the field of leadership and has overcome them will be most understanding of the problems of others and, therefore, a most effective coach. Second, the effort and drive developed in becoming a good leader the hard way will serve a man well in the art of leadership.

Dealings Require Sincerity

5. In the paragraph concerning "Prior to Promotion," the dialogue relating to the gradual increase of responsibility for the trainee and relating also to "testing the trainee" gave me the feeling that the trainee might, under the circumstances, be subject to criticism as being the fair-haired boy. I believe the subject should be frankly and discreetly discussed with the group. The point that the trainer might ask the trainee to make a decision which already has been inwardly made by the trainer smacks slightly of insincerity. The keenest trainees, and, therefore, most valuable people, will be first to sense any insincerity and perhaps resent the fact that they are being "handled." While the case in point is relatively minor, it brings out a vital necessity of complete, scrupulous sincerity in all dealings of this sort, a point which deserves maximum attention.

6. The points made in the section headed "After the Promotion" were pleasing in the sense that they

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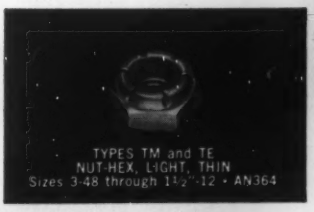

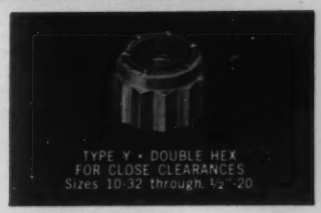

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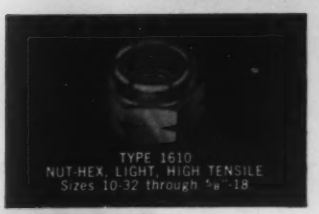

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Professional Viewpoints

were most pertinent and well put. Some tendency to adopt the technique used in pseudopsychological writing was noted in that the relatively easy to discover things to do or not to do are noted while the more difficult methods for accomplishing these things are not mentioned. This might be the subject of further writing in this field. I refer specifically to the admonishment that a supervisor should "delegate responsibility." I feel sure the author recognizes that this is an art which can be developed by specific procedures.

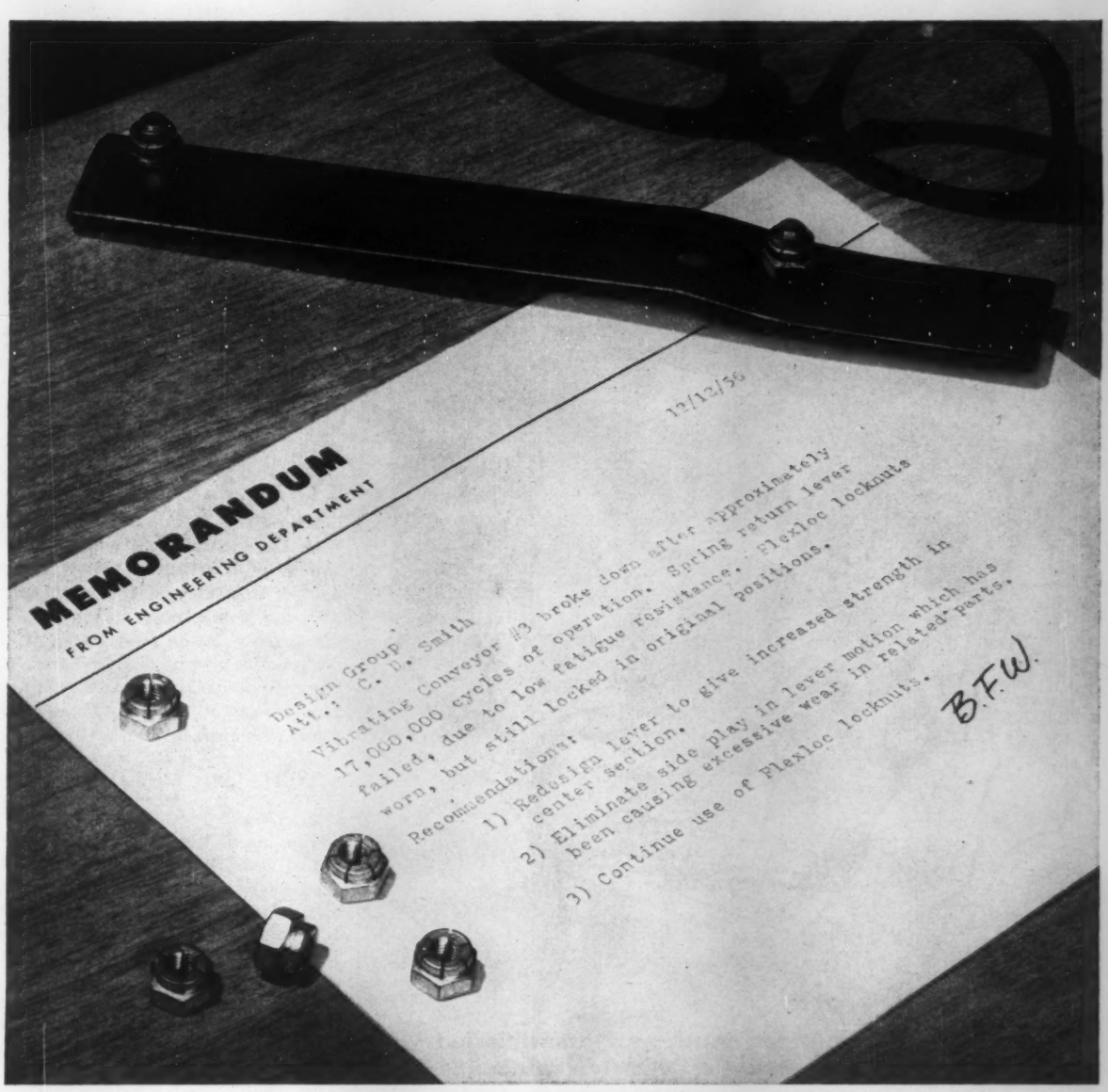
7. References to various functions of supervision and, in the final paragraphs, to "Leadership" as an art appears to me to be most apt. All arts involve knowledge of the theory plus ample practice in any given field. Management certainly falls into the category of art in this respect. Mention is made of the need for a supervisory trainee to have ample and free opportunity to practice his art. This point has been neglected too often because of the fear that the trainee will make mistakes. The loss to the employer of the training to the supervisory trainee very often more than offsets the cost of mistakes trainees will make, provided, of course, that the trainees are truly ready to supervise.

—ROBERT W. JENNY
Supervisor,
Mechanical Development Group
Applied Physics Staff
Boeing Pilotless Aircraft Div.
Seattle, Wash.

. . . different solutions can exist harmoniously . . .

To the Editor:

Mr. Jenny's letter was most interesting to me, in that I found his points well taken; however, I might add that we still have differences of opinion on certain points. This seems only natural, since engineering management is an art, not a science. Consequently, different solutions to the same problem can exist harmoniously, since the truth is relative—relative to the situation, or the environment, in which



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the problem exists.

Most of what I wrote in my article is based on my own experience—both as a trainee and as a trainer. In my opinion, the procedure has been successful; however, it doesn't necessarily follow that it is the only procedure to use and therefore, that it must be vigorously followed.

Points where Mr. Jenny and I differ are:

1. He mentions that he feels that leadership traits "basically do exist in everyone," and that those who have the most difficult time in becoming good leaders may very often be the best leaders. I agree with the second part, since I have found no correlation between the ease or difficulty of transition and ultimate competence. However, I disagree with the first part, since I have had personal experience, in more than one case, with individuals who were basically not suited for supervision.

Selection from Above

2. With reference to the techniques used "Prior to Promotion," I feel that this approach can still be sincere. Basically, the trainee has to realize that he cannot be *given* control of the group until he has *taken* control of the group. I disagree with discussing the selection with the other members of the group. The very structure of the group—having a designated leader—implies that the organization is essentially autocratic, not democratic, and in times of stress this is readily apparent. Primarily, the selection of a leader must come from above *first,* and be followed by consent from below.

In general, it seems to me that we are basically in agreement, though there are some variations. However, were there no variations, there would be no stimulus to discussion, and the subject would be very dull—which it certainly isn't!

—H. M. ELLIOTT
Manager,
Computer Devices Engineering &
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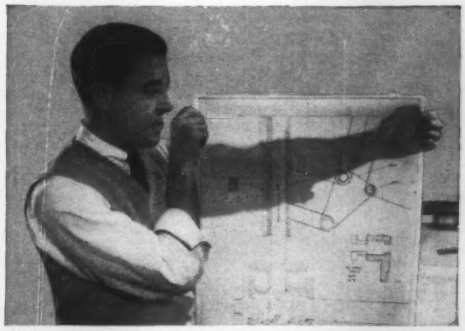

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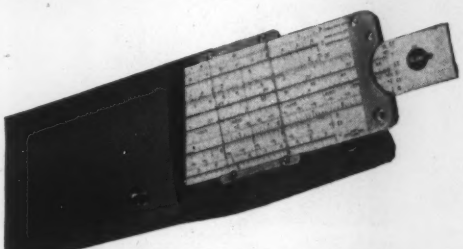

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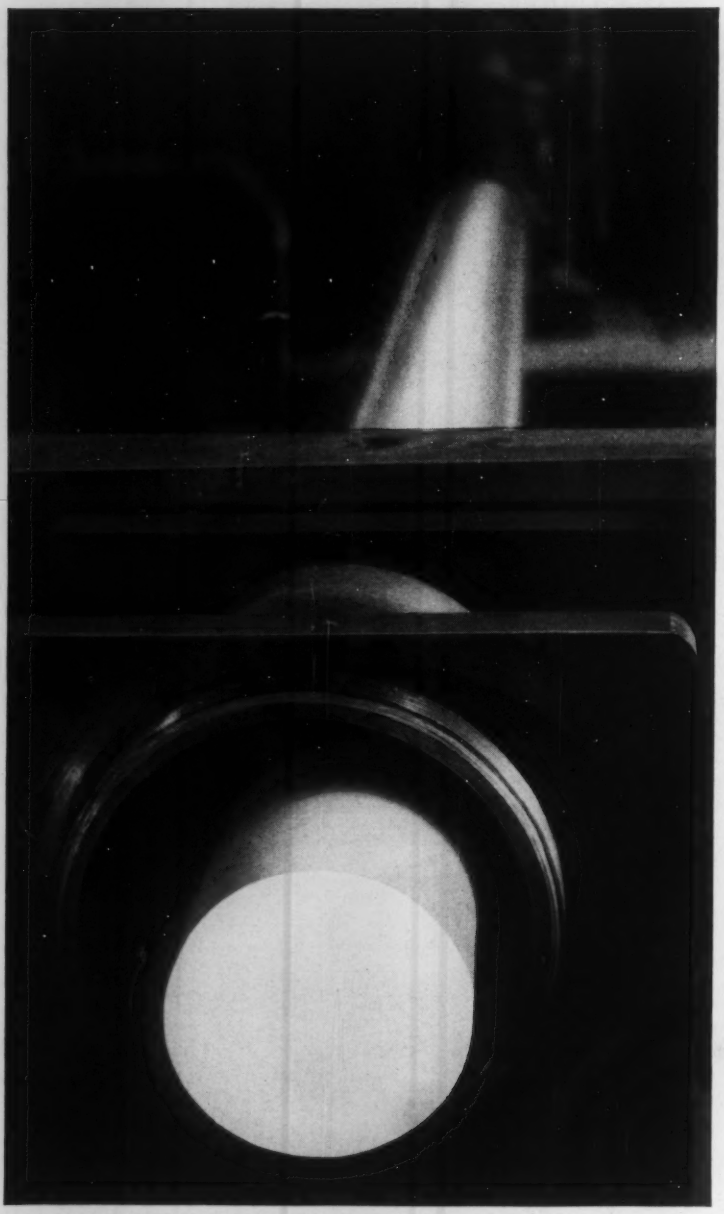

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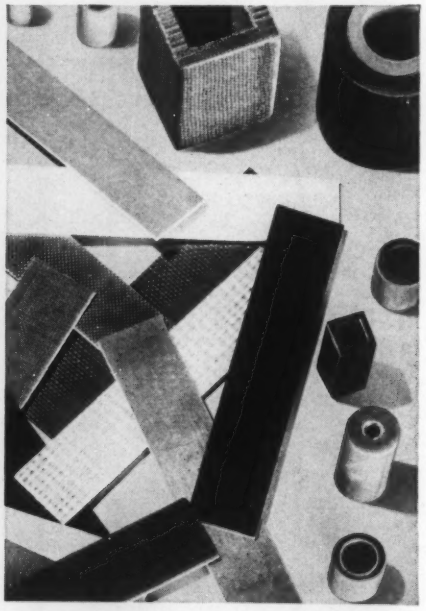

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Circle 590 on Page 19

THE ENGINEER'S

Library

Recent Books

Nuclear Chemical Engineering. *By M. Benedict and T. H. Pigford, both of Massachusetts Institute of Technology; 594 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$9.50 postpaid.*

Materials of importance for nuclear reactors, and the novel processes which have been developed to concentrate, purify, and separate these materials are described fully in this volume. Introduction to these materials is by means of the relationship between nuclear reactors and associated production plants. Principles of nuclear physics pertinent to the processing and separation of isotopes are discussed.

Included are sections on the properties, occurrence, concentration, purification, and conversion of uranium, zirconium, hafnium, thorium, and beryllium.

Magnesium Casting Technology. *By A. W. Brace and F. A. Allen; 174 pages, 5½ by 8½ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; $4.95 per copy.*

This book correlates basic principles of magnesium founding and features an objective presentation of both American and British practice.

Contents include magnesium casting alloys, melting practice, fundamentals of die design, pressure diecasting, heat treatment of castings, significance of mechanical tests, surface treatment, design characteristics of castings, tolerances, alloy properties, and applications.

Polyethylene. *By Theodore O. J. Kresser, Spencer Chemical Co., Kansas City, Mo.; 217 pages, 5 by 7½ in., clothbound; published by and available from Reinhold Publishing*

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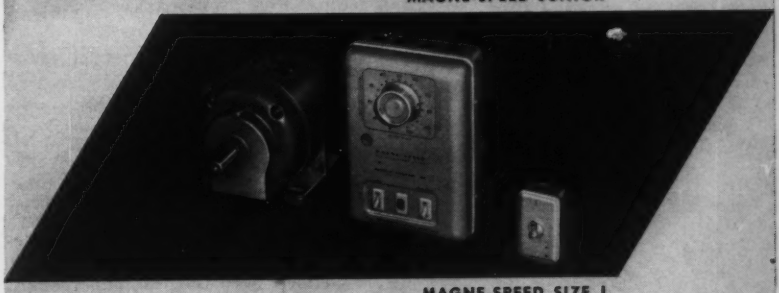

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SIZE II	¾, 1 and 1½ HP	50:1	S-580

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Circle 592 on Page 19

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Corp., 430 Park Ave., New York 22, N. Y.; $4.95 per copy.

This first book of a new plastics applications series treats of the practical aspects of polyethylene including its use, composition, and production.

Applications of polyethylene are treated in a selective manner, and each represents a group of related applications. Topics include general properties of polyethylene, chemical structure, production, processing, film and coating applications, and extrusions.

Transistor Electronics. *By David Dewitt and Arthur L. Rossoff; 381 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$8.00 postpaid.*

This book presents the properties of the transistor and its underlying physical mechanisms. It provides step-by-step treatment of transistor circuit design without requiring a previous knowledge of quantum mechanics.

Included are fundamental processes in semiconductors, elementary quantum mechanics, and behavior of carriers within a crystal.

Government Publications

Naval Electronics Laboratory Reliability Design Handbook, PB 121839. *6 sections, 8 by 10½ in., paperbound; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C., $3.00 per copy.*

This design handbook presents information on ways of achieving simplicity, economy, and reliability in electronic equipment. It is intended to serve as a medium through which information on new materials, processes, techniques, and design aids will be distributed.

The basic volume presents methods of achieving preferred circuitry, construction techniques, design procedures, and application data. Insertion sheets, to be distributed later at frequent intervals, will contain material furnished by NEL engineers, scientists, and other technical personnel on almost any subject related to the preceding topics. Proposed stand-

Simplified drawing based on photo shows ANGLgear application on Texas Inking Machine Co. belt finishing machine. Change from exposed miter gears to ANGLgears solved noise, lubrication and safety problems.

Texas Inking Machine Co., Stafford, Tex., recently developed a machine that automatically polishes and dyes the edges of leather belts. The design involves several 90° drives, and on early models these created problems. "We used exposed miter gears which gave us constant trouble in regard to noise, disengagement, lubrication failures, and the danger of entangling the women operators used so extensively in this industry," Texas' chief engineer recalls. "Now — with ANGLgears—we have a quiet, safe operation and complete confidence in our machine."

Perhaps ANGLgear can solve a 90° power takeoff problem for you. Completely enclosed and permanently lubricated, ANGLgears are available from stock in ⅓ to 5 hp ratings, with 2 or 3-way shafting, and 1:1 or 2:1 gearing.

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Circle 593 on Page 19

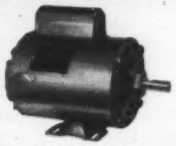
WAGNER ELECTRIC MOTORS...THE CHOICE OF LEADERS IN INDUSTRY

Reduce Down Time—Power your Product with *Dependable* Wagner Motors

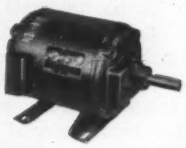
Sixty-six years of experience goes into the building of Wagner Motors. Their reputation for reliability, their electrical characteristics, price and prompt delivery make them a sound choice for your product.

Whatever your motor requirements may be—single-phase or polyphase... ⅛ or 500 horsepower—Wagner can offer a standard motor that is entirely dependable in its specific application. A few of the many motors in the Wagner line are shown below.

FRACTIONAL HP

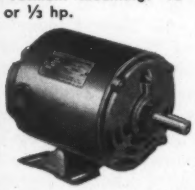


TYPE RK — Capacitor-start Induction. For general purpose applications. Single-phase. Rigid or resilient mounting. 48 frame: ⅛ or ¼ hp. 56 frame: ⅓ through ¾ hp. Also available in integral ratings through 5 hp.



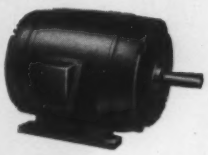
TYPE RA — Repulsion-start Induction. For general purpose applications. Single-phase. High starting torque—low starting current. ⅛ through ¾ hp. Also available in integral ratings through 15 hp.

TYPE RB — Split-phase Induction. For easy starting applications. Single-phase, resilient mounting. 48 frame: ⅛, ¼ or ⅓ hp.



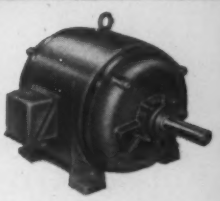
TYPE RP — Polyphase Squirrel-cage Induction. General purpose, normal torque. 56 frame: ¼ through ¾ hp.

INTEGRAL HP

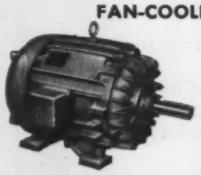


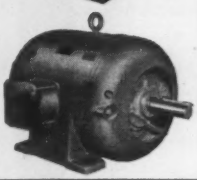
DRIP-PROOF

TYPE DP—Squirrel-cage Induction, corrosion resistant cast iron frames. 1 through 125 horsepower.

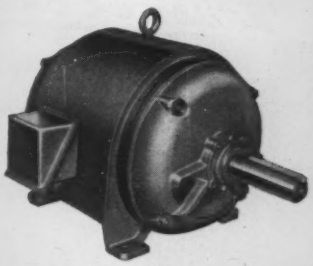


TOTALLY ENCLOSED FAN-COOLED





TYPES EP AND JP Standard and explosion-proof. Squirrel-cage Induction, corrosion resistant cast iron ribbed frames, 1 through 30 hp—smooth frames, 40 through 250 hp.



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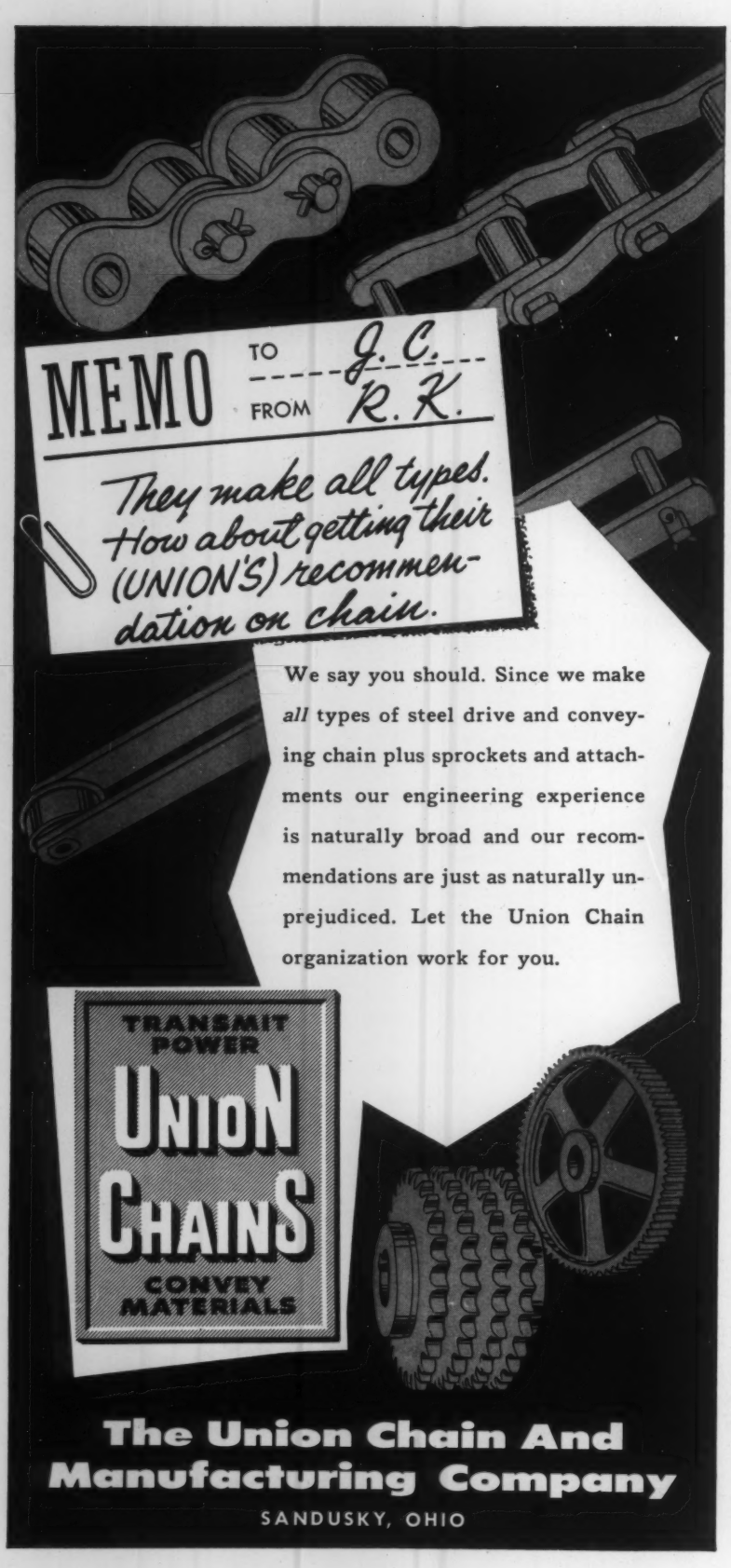


Library

ards will be included.

Major topics of the basic book include equipment design; environmental, electrical, and mechanical considerations; materials, circuits, tubes, and electromechanical components.

Screw-Thread Standards For Federal Services, 1957. *208 pages, 7¾ by 10¼ in., paperbound; available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.; $1.25 per copy.*

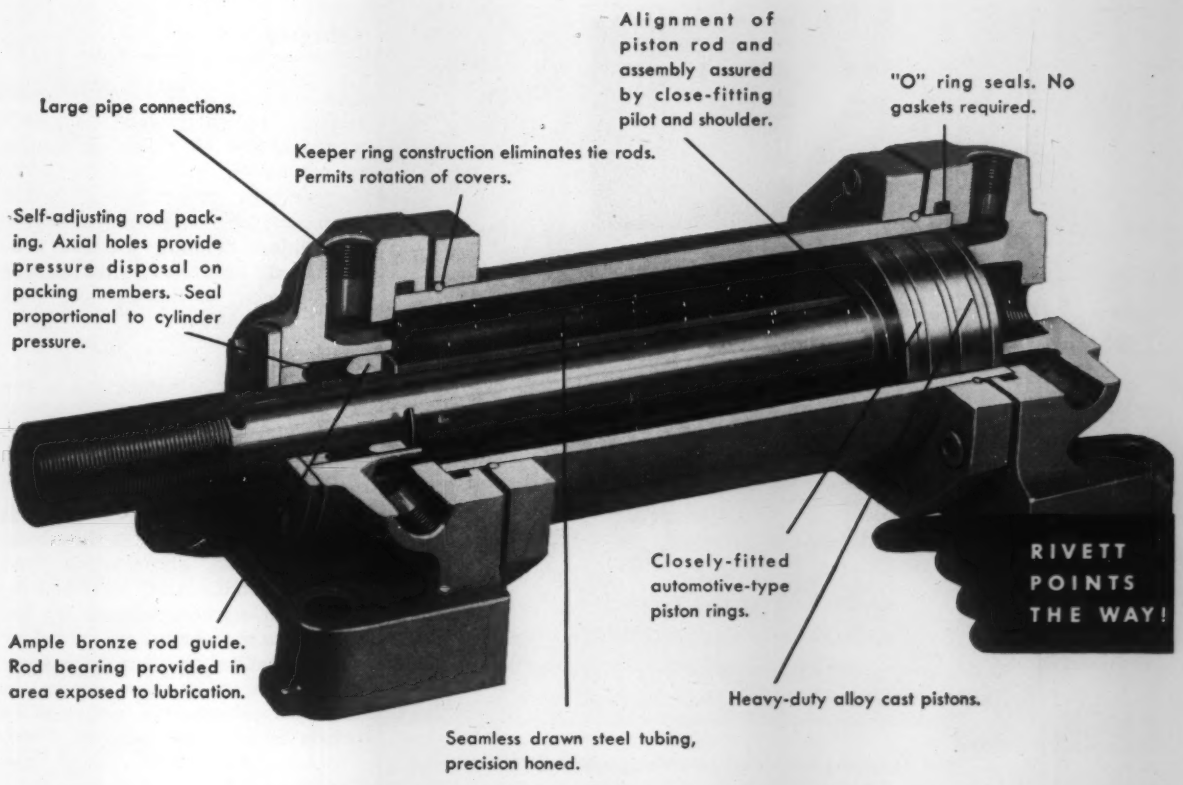
This publication represents the work of the Interdepartmental Screw Thread Committee, sponsored by the Departments of Defense, Army, Navy, Air Force, and Commerce to promote uniformity in screw-thread standards in Departments concerned.

Current work will be issued in three volumes or parts; this volume, Part 1, contains six sections covering definition of terms relating to size, fit and dimensions of screw threads, form and thread series for bolts, special diameters, miniature screw threads, and gaging for Unified, American, and American National threads. Part 2 will include standards for hose-coupling, pipe, and gas cylinder threads and will be issued when the revised standards have been completely formulated. This will be followed by Part 3, which will include Acme, Sub-Acme, Buttress, and other standard threads.

Investigations of Alloys of Magnesium and Their Properties, WADC Technical Report 56-88, PB 121801. *By Foerster, Couling, Baker, and Johnson, all of The Dow Chemical Company; 84 pages, 8¼ by 10¾ in., paperbound; published by Wright Air Development Center; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; $2.50 per copy.*

Three separate major studies on magnesium alloys are discussed in this report. The first deals with development of improved wrought alloys, the second with thermal and electrical properties of the alloys, and the third with plastic deformation and preferred orientation of wrought alloys.

Topics include chemical analysis



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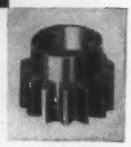

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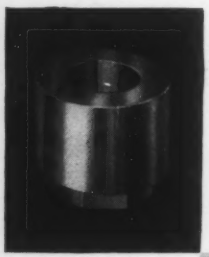

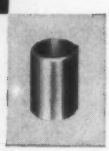

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of magnesium alloys, properties of sheet and extrusions, creep strength and corrosion resistance of extrusions, pellet alloys, room-temperature properties of pellet extruded high-temperature alloys, mechanical twinning in cold rolling, and data on simultaneous measurement of thermal and electrical conductivity.

Atomic Energy Facts. *216 pages, 8 by 10½ in., paperbound; available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.; $2.00 per copy.*

Devoted entirely to peaceful uses of atomic energy, this book describes the organization and functions of the AEC, technical information services offered by the Commission, conditions under which qualified individuals and organizations may gain access to classified information, and how to obtain licenses and patents.

Other discussions cover the Commission's programs for training and education in nuclear science and technology, activities of major AEC contractors, raw and feed materials, reactor developments, and radioisotope development. Eight appendices cover principles of controlled thermonuclear programs, categories of restricted data available to access permit holders, depository libraries of AEC, reactor data tables, and a catalog of materials standards.

Alumina-Base Cermets, WADC Technical Report 54-173. *By Charles A. Hauch, Ernest W. Deadwyler, and Thomas S. Sherlin, all of the Ohio State University Research Foundation; 8¼ by 10¾ in., paperbound; published by Wright Air Development Center; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.;*

PB 121253, *Part 2—37 pages; $1.25 per copy.*
PB 121461, *Part 3—39 pages; $1.25 per copy.*

This report presents results of studies on five new alumina-base cermets in which metal contents range from 50 to 95 per cent by volume.

Alloys investigated include 80 Ni, 20 Cr; 65 Co, 30 Cr, 5 Mo; 66

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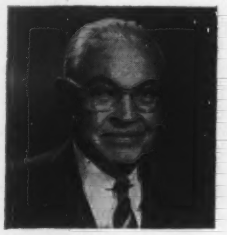


Technical-ities

By John S. Davey

Fastener coatings

Salt spray testing of various metallic coatings used on fasteners doesn't always give a true picture. In actual service, accelerated test results are not always borne out.

Reason: The tests favor the coatings which can endure continuous moisture and salt atmospheres, whereas some do better under the normal intermittent dry and wet conditions of weathering.

Experience has developed a "scale" of suitability of various coatings for fastener protection.

FOR RUST PROTECTION

Hot galvanizing offers greatest endurance under most conditions. It falls short on highly stressed fasteners.

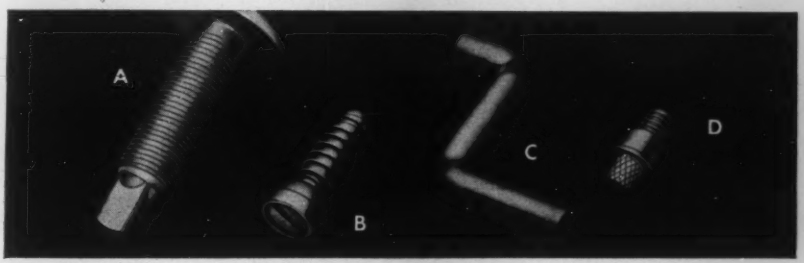
Electrodeposited zinc is next most practical – providing good appearance, controlled tolerance at threads, and ability to take high bolt tensions.

Cadmium plate stands out where salt atmospheres predominate. Not suitable for contact with edibles, it is ruled out for many appliances.

For general applications, the rust prevention of black oxide coatings proves satisfactory. Phosphate coatings, too, offer some degree of protection, but not under severe conditions.

Chromium, plated over copper, should be considered more for its appearance on fasteners rather than protection.

Cold heading creates quality parts the low cost way



No value analysis of product components is really complete without exploring what cold heading machines can do to cut costs. Some examples:

A. ELIMINATE EXTRA OPERATIONS. Leveling screw, formerly made by riveting flat disc to set screw, now emerges as a stronger, single piece from a cold header.

B. ONE PIECE BETTER THAN TWO. Cold headed hose clamp screw has integral flange which, after head is slotted, is forced up to form screwdriver shield. Before, piece was in two parts . . . with screw made on screw machine, and the shield a stamping fitted around head during assembly.

C. FASTER THAN FORGING. Shifter lever is bent into double "L" automatically in bolt header . . . replacing 2-stage forging operation. The header does it at high speed from continuous rod.

D. METAL FLOWS TO SHAPE—NO WASTE. No longer cut on screw machine, insert screw for plastic parts costs 40% less. Cold header uses just the amount of metal required. The threading and knurling, too, are done automatically at high speed.

Metal forced to cold flow into shape results not only in savings but also in stronger parts. With uncut flow lines, the piece is better able to withstand stress concentrations.

For an expert opinion on parts you now use, check with Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

12-point fasteners cut wrench clearance space

Double hex RB&W bolts and nuts measure smaller across their points than single hex fasteners. Used with an *external* socket wrench, they permit optimum driving torque to be applied.

Thus, while permitting design of more compact assemblies, these fasteners also assure proper preloading for stronger connections.

Available with plain flange, or SPIN-LOCK design which incorporates teeth that embed upon tightening and resist loosening under vibration or temperature changes.

Circle 598 on Page 19

HIGH CAPACITY SWITCH

Controls up to 4 circuits

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DUST, OIL-TIGHT
LONG LIFE
VERSATILE
LONG OVERTRAVEL

Machine tool and other equipment applications are "naturals" for this Acro high capacity switch, which can control up to four separate circuits on either pilot or line duty. Actuator is adjustable 360° in two planes.

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2 H.P. 230 Volts A.C.
1 H.P. 115 Volts A.C.
20 Amps—250 Volts A.C.

Two types available: Double Action Type actuates switch contacts when actuator is moved either side of "at rest" position. Single Action Type operates from one side of "at rest" position only. Both are designed for long life under heavy use.

AVAILABLE TYPES

Catalog No.	Circuit Arrangement	No. Terminals	Action
242-0003-03	Four circuits (two open, two closed)	8	Double
242-0011-03	Four circuits (two open, two closed)	8	Single
242-0010-03	Double circuit (one closed, one open)	4	Double
242-0012-03	Double circuit (one closed, one open)	4	Single
242-0019-03	Double circuit (normally closed)	4	Double
242-0017-03	Double circuit (normally closed)	4	Single
242-0020-03	Double circuit (normally open)	4	Double
242-0018-03	Double circuit (normally open)	4	Single

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Ni, 18 Cr, 16 Te; 76 Cr, 24 Ti; and an 18-8 type stainless steel.

Details include fabrication techniques and test results as well as wettability studies of alumina by various alloys.

Naval Research Technical Reports. *Each publication is 8 by 10½ in., paperbound, side-stapled; copies available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

The following Technical Reports are available:

PB 121372. Properties of Bolts Under Shock Loading. 37 *pages;* $1.25 *per copy.*

PB 121514. The Relation of Heat Treatment to the Dynamic Properties of Some Carbon Steels. 14 *pages;* 50 *cents per copy.*

PB 121776. Design of Minimum Weight Magnetic Cores. 7 *pages;* 50 *cents per copy.*

PB 121933. Fracture Characteristics of Copper-Base Alloys. 11 *pages;* 50 *cents per copy.*

Wright Air Development Center Technical Reports. *Each publication is 8¼ by 10¾ in., paperbound and stapled; copies are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

PB 111838. Investigations of Deformation and Fracture of Metals. 21 *pages;* 75 *cents per copy.*

PB 121497. Mechanical Property, Corrosion and Welding Studies on 6066 Aluminum Alloy. 29 *pages;* $1.00 *per copy.*

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NUCLEAR POWER applications have created demands for entirely new types of materials. A good example is borated stainless steel—a metal whose high neutron cross-section is important for shielding and control rods. Conventional air-melting, however, limits the boron content to 1%. But Vacuum Metals is producing *fully workable* stainless alloys with 2% boron—even higher percentages experimentally.

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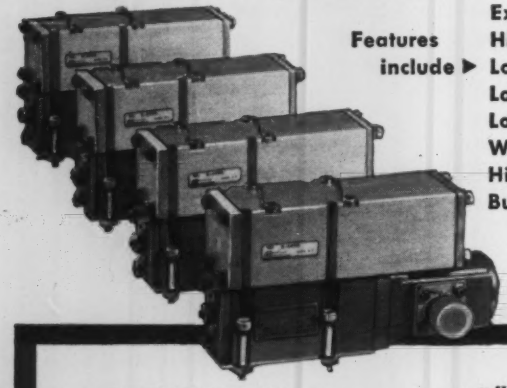

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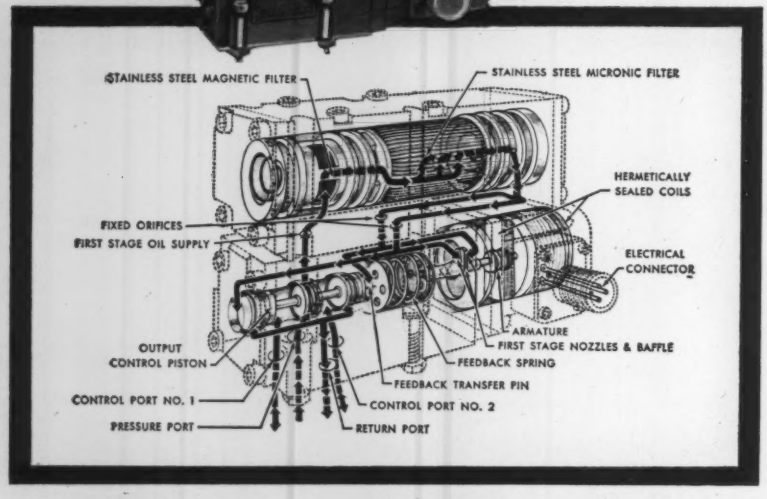

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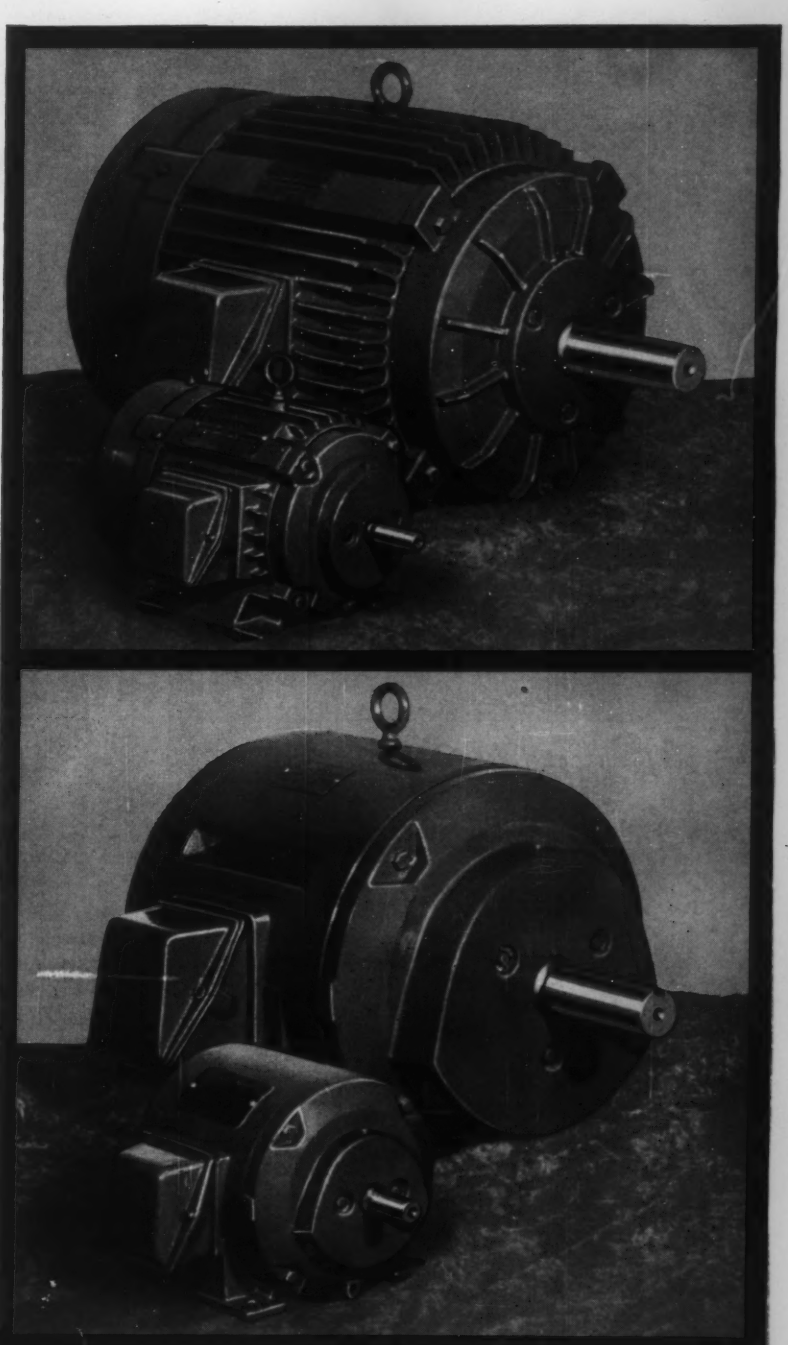

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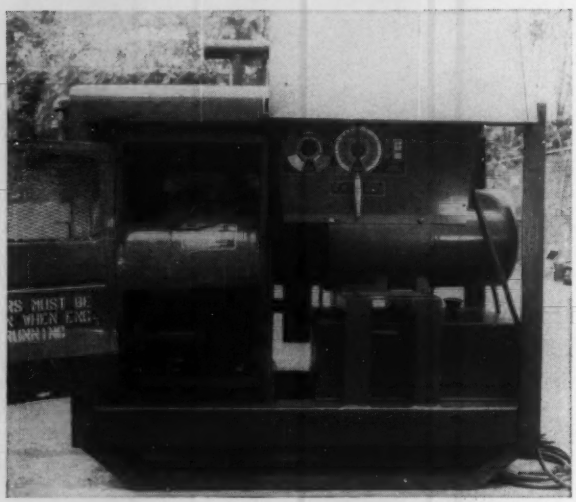

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On-the-job service is what counts most in an engine. Here, for example, is a brief summary of a service report covering the performance of the Model VR4D 56 hp. Wisconsin Heavy-Duty AIR-COOLED Power Unit which drives the 400 Ampere Arc Welder illustrated above:

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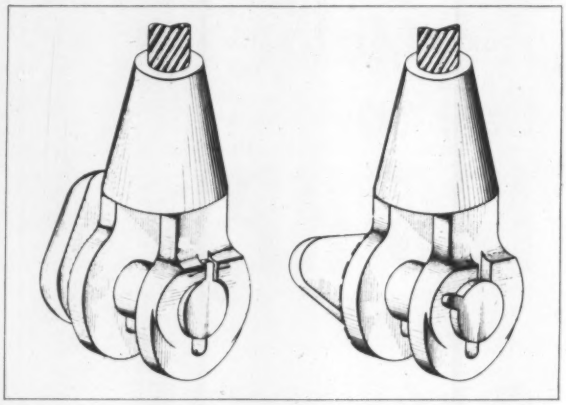
NOTEWORTHY

Patents

Spring-Locking Clevis

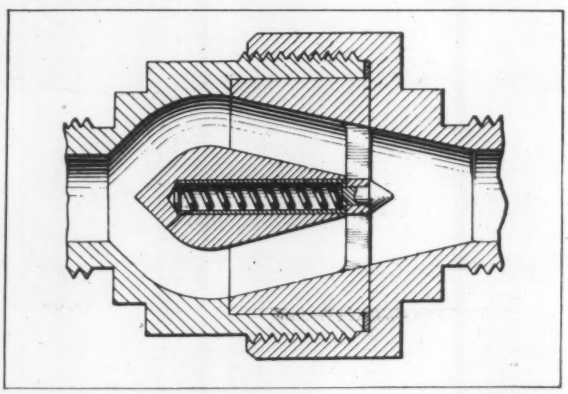
Spring force is released from the locking pin of a safety clevis when the latch-lug engages the latch recess. Design facilitates the release of larger size clevises employing substantial spring loadings. Pin



is free to be withdrawn from the saddle when the lug is rotated to align with the pass-through notches. During assembly of the clevis, rotation of the palm knob forces the locking lug up the cam surface (right), compressing the spring washer and allowing the lug to snap into its recess. *Patent* 2,809,856 *assigned to George E. Failing Co. by Emmett L. Alexander.*

Cushioned-Action Check Valve

Minimum flow restriction is provided by a teardrop shaped poppet and contoured flow-passage walls in a check valve with cushioned action. Light coil spring biases poppet to the closed position; fluid flow (left to right) moves poppet to open position. Air



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new Parker Cold Bonderite System does it!

Turn down the heat! Put most of your Bonderite line heat costs back in the till! Parker Rust Proof Company has developed a new Bonderite system for low temperature operation.

It includes a new cold alkaline cleaner that works beautifully at 70° and is effective in a temperature range from 60° to 120°. A new Spra-Bonderite, specially formulated to produce a superior coating at low temperatures, has been developed to work in conjunction with the new Parker cold cleaner.

With the new cold Bonderite system, savings are really sizable. Heat consumption in the line is cut by as much as 70%. Cost of the new Parker system is approximately equal to conventional alkali cleaners and phosphate coating chemicals, so the savings in heat are practically all velvet. It is estimated that on an average automobile body line the savings in steam costs can run as high as 10 to 12 cents per body; on an average refrigerator line 4 to 5 cents per cabinet. Savings in B.T.U.s can mean savings in dollars.

The new cold Bonderite system has been production-tested in mass production plants. Its performance has amazed the experts. It's ready to go to work in your plant, saving you money, right now!

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2 **DETERMINE YOUR APPLICATION REQUIREMENTS.** Over-design and under-design both waste money.

3 **CONSULT A FASTENING SPECIALIST.** Do this before finalizing your design. His suggestions may lead to a simpler, lower-cost answer.

4 **DON'T MAKE SPECIALS YOURSELF.** It actually costs *less* to use a dependable, experienced screw manufacturer. No hidden costs, no tie-up of your valuable men and machines.

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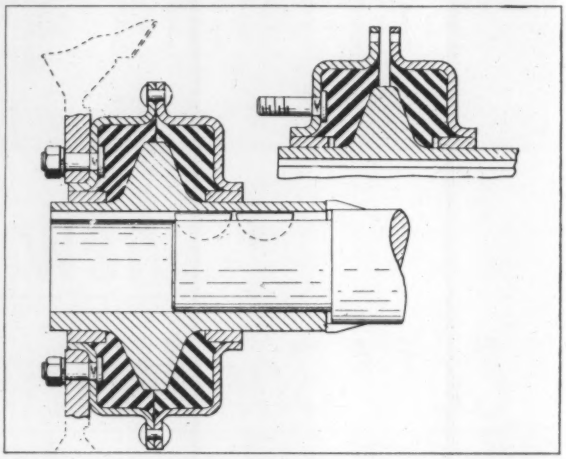
MAC-IT hex socket alloy cap & set **SCREWS**

Noteworthy Patents

pocketed in clearance between the end of the poppet-support stem and the poppet bore escapes slowly as valve opens and re-enters as the valve closes. Result is to provide a dash-pot action which stops vibration and chattering of the poppet on its seat. *Patent* 2,809,660 *assigned to Aeroquip Corp. by Alvin Louis Becker.*

Vibration-Absorbing Fan Mounting

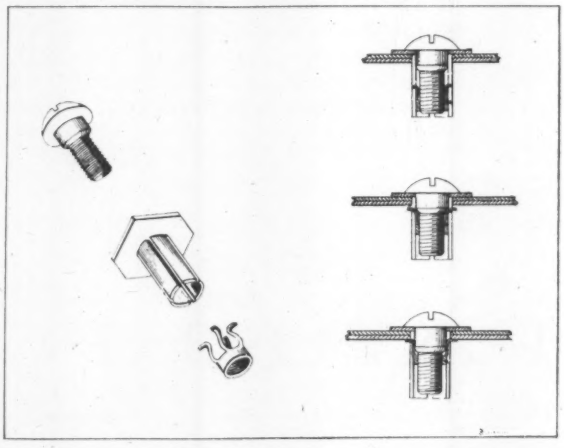
Rubber rings, bonded to formed retaining covers, damp out vibration transmitted from fan blades to hub in a compressed-rubber fan-mounting design. Be-



cause flexible elements are constrained against radial expansion during clamping (right to left), blades and hub are maintained in concentric alignment. Tilting of the fan during operation is prevented by bronze rings which ride on the steel hub. *Patent* 2,802,353 *assigned to H. A. King Co. by Thomas H. Peirce.*

Blind Fastener

Blind fastening of materials of varying thickness can be accomplished by means of an expanding fastener. Comprising bolt, sleeve and nut sections (left),



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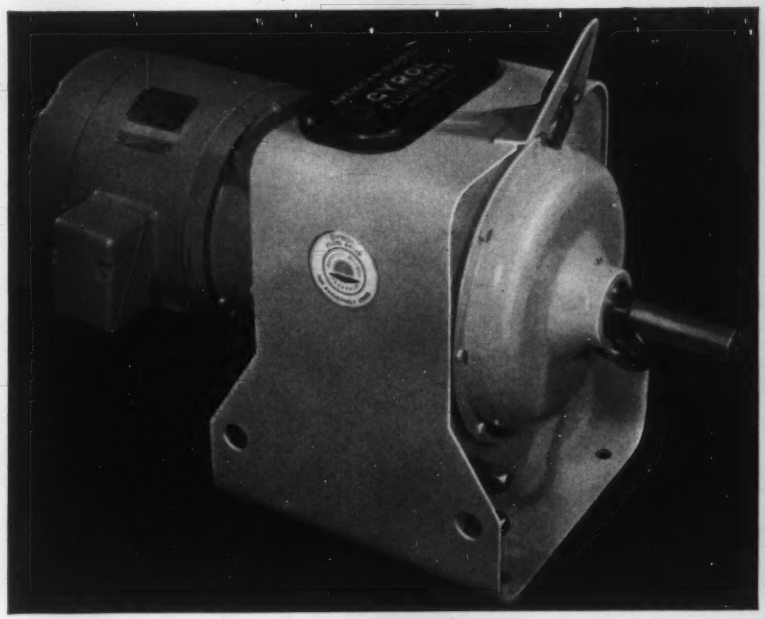

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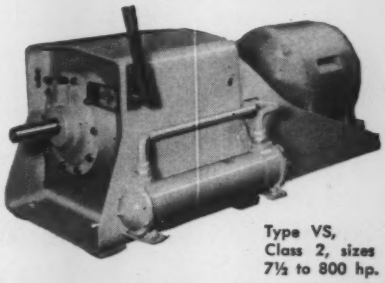

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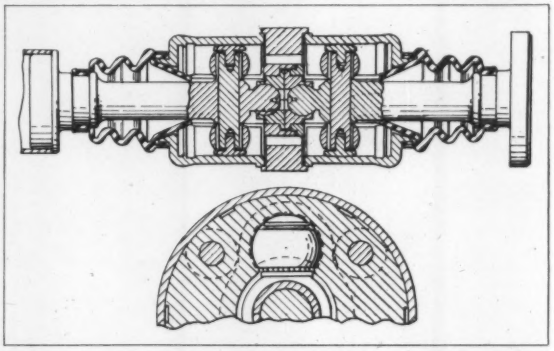
Noteworthy Patents

the unit is inserted through a drilled hole and tightened with a screw driver to draw the nut against the inaccessible work surface (right). Easily disassembled, the fastener design accommodates pieces of widely varying thicknesses. *Patent* 2,805,597 *assigned to Preferred Engineering and Research Corp by Bernard T. O'Shaughnessy.*

Two-Section Universal Joint

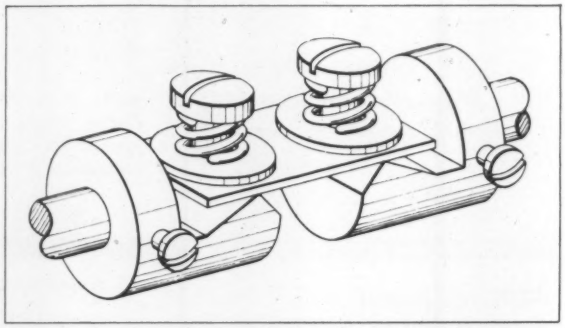
Spacer and coupling arrangement interconnects two conventional ball-and-socket sections in a constant-



velocity universal joint. Design, which utilizes standard parts where possible, minimizes or eliminates lubrication and alignment problems inherent to conventional universal-joint assemblies. Use of two ball-and-socket sections has advantage that each unit need accommodate only one-half of the total angular displacement between shafts. *Patent* 2,755,641 *assigned to Chrysler Corp. by George E. Dunn.*

Shaft Coupling

Transmission of rotary motion with virtually zero backlash is provided by a universal-joint coupling designed for low-torque applications. Unit employs a



flat connecting plate, which pivots on knife edges on the hubs, to couple the shafts. Fabricated of metal or of ceramic for circuit isolation, the plate can be riveted to the hubs, or spring-screw mounted as shown to give torque-limiting effect and additional flexibility for misaligned shafts. *Patent* 2,802,-350 *assigned to Collins Radio Co. by Charles E. Ottaway.*

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Circle 608 on Page 19

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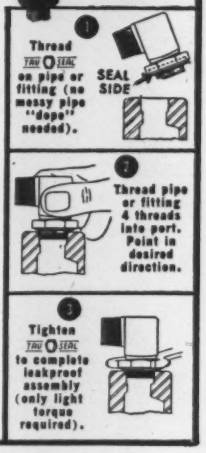

Circle 609 on Page 19

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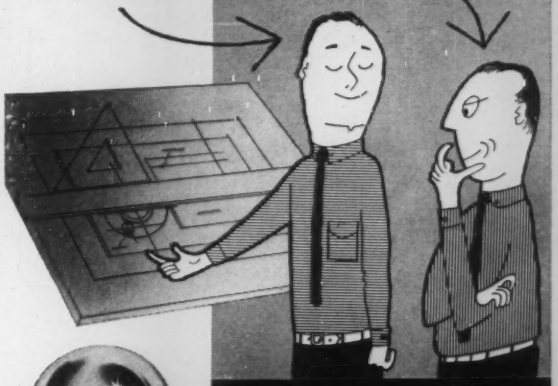

How right these engineers are, for the modern Hartford Ball is an extremely high precision component that costs very little for the myriad of important jobs it performs.

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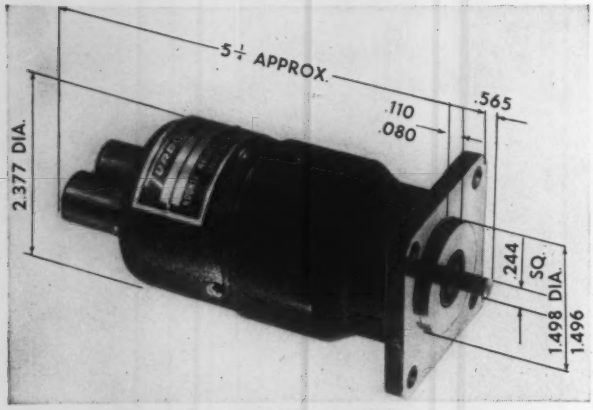
Circle 610 on Page 19



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Circle 611 on Page 19

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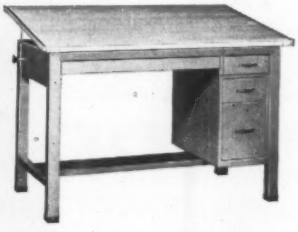


MAYLINE

Circle 612 on Page 19

CLOSURES

- Metal or Plastic Caps or Plugs to protect threads, tubes, machined parts, reamers, cutters, tools.
- Protect against thread damage, dust, dirt, and moisture.
- For inside and outside application. All sizes. Immediate delivery.

Clover closures are made in metal and tough plastic polyethylene. They are made in caps, plugs and special shapes to fit parts tightly, offering completely sealed protection during manufacture, shipping and storage. Backed by years of closure experience. Write for low prices and complete information.

Send coupon today!

METAL
Threaded caps for AN & SAE external threaded parts.

PLASTIC
Tapered parts for use either as a cap or plug.

METAL
Threaded plugs for AN or SAE internal threaded parts.

PLASTIC
(L.T. Series)
Non-threaded push-on caps for tubing, AN & SAE Fittings, reamers, etc.

Gentlemen:

Please send samples and prices of closures in
Polyethylene ☐ Aluminum ☐

Name.....

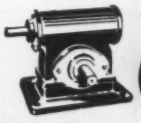
Address.....

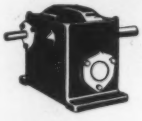
City.....

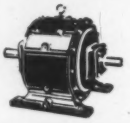
CLOVER INDUSTRIES, INC. 596 Young Street Tonawanda, N. Y.

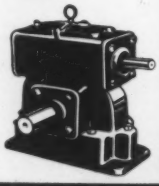
Abart SPEED REDUCERS

Designed and Constructed for Continuous Rugged Service









trouble-free, economical drives for any speed reduction need

Compact, precision built Abart units are available in a wide range of models from fractional to 168 hp. ratings, ratios to 10,000 to 1.

Worm, spur and combination gear models—single or double reduction—are supplied in 75 different types and sizes with any desired shaft arrangement.

Write today for Abart's hand pocket size speed reducer catalog.

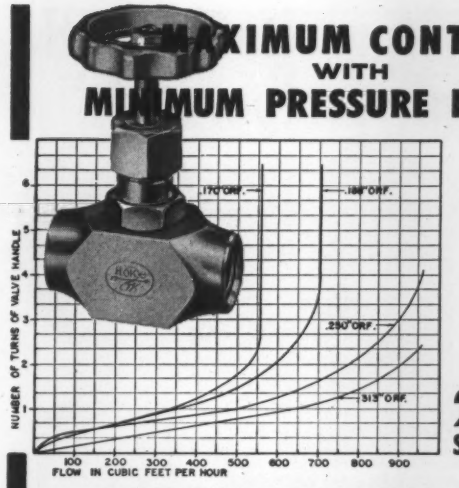
ABART GEAR and MACHINE CO.

4821 WEST 16th STREET • CHICAGO 50, ILLINOIS

Circle 613 on Page 19

Circle 614 on Page 19

MAXIMUM CONTROL WITH MINIMUM PRESSURE DROP



270 SERIES

BAR STOCK VALVES

This flow curve for air at 30 psi shows the excellent control obtainable with minimum pressure drop in Hoke's 270 Series bar stock needle valves. The O-ring stem seal will pass a helium leak test... and there's no packing adjustment, no friction even at high pressures. Self aligning stem shuts off tight. For hydraulic and pneumatic equipment, gas analysis, pilot plants, test instruments of all types. ⅛" to ½" pipe sizes in carbon, chrome or stainless steel and brass.

HOKE

HOKE INCORPORATED
Fluid Control Specialists
191 S. Dean Street, Englewood, N. J.

Circle 615 on Page 19

Young 3-1-2
COOLING SYSTEM TREATMENT

Rust and Corrosion Inhibitor

Young 3-1-2 is a complete protective treatment for the cooling systems of diesel, gas and gasoline internal combustion engines. It prevents rust, controls scale, and protects aluminum, copper, ferrous metals, etc., from corrosion; and non-metals from deterioration.

Young 3-1-2 is furnished in pellet form, and since it is a *non-chromate* type treatment, it is non-irritating to the skin. No weighing or measuring is required: *3* pellets to *1* gallon of coolant, 2 times a year (under normal operating conditions) are recommended.

Young 3-1-2 will not deteriorate with age when stored in a dry area. It is compatible with all types of standard anti-freezes.

For further information write Dept. R307-M

Young RADIATOR COMPANY
RACINE, WISCONSIN
Creative HEAT TRANSFER ENGINEERS
Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

Circle 616 on Page 19

Top Tube Performance can cost up to 40% less:

specify

ALCOA UTILITUBE

for fuel, air, hydraulic and oil lines

ALCOA® UTILITUBE, the coiled aluminum tube, actually costs as much as *40% less* per foot than copper tube. That saving becomes more important when you realize that it comes with no sacrifice in performance and quality. You can count on ALCOA UTILITUBE for dependable service in fuel, air, gas and hydraulic lines. Here's why:

LONG LENGTHS—available in economical lengths up to 1,000 feet.

EASY WORKABILITY—bends easily, work-hardens less.

HIGH FATIGUE STRENGTH—stands up well under vibration.

CORROSION RESISTANT—resists most industrial atmospheres, many gases and liquids.

LIGHT WEIGHT—⅓ weight of copper; long lengths easier to handle.

NO SLUDGE OR GUM—will not contribute to the formation of sludge or gum in lubricating oils, gasoline.

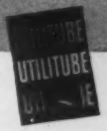
AVAILABILITY—your distributor carries ALCOA UTILITUBE in stock.

FITTINGS—readily available in aluminum from several manufacturers.

Get dependable tube service for less: *Specify Alcoa Utilitube* for your coiled tube needs. Use the coupon to get complete details in the FREE BOOKLET, *Alcoa Utilitube*.

® Registered T.M. of Aluminum Co. of America

ALCOA ALUMINUM



ALUMINUM COMPANY OF AMERICA
909-M Alcoa Building
Pittsburgh 19, Pa.

Please send me the free booklet, *Alcoa Utilitube*.

Name_____ Title_____

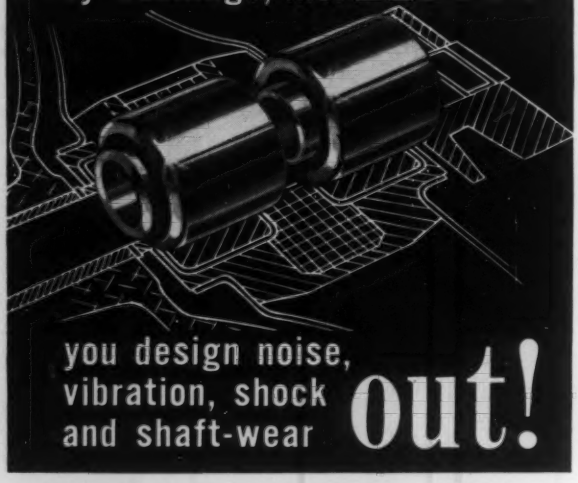
Company_____

Address_____

City_____ Zone_____ State_____

Circle 617 on Page 19

when you design • Flexible Bearings by Bushings, Inc. **in...**



you design noise, vibration, shock and shaft-wear **out!**

Custom fabrication by Bushings, Inc. can assist in solving your bearing problems

Whatever you design or manufacture with moving parts—from small appliances to heavy earth moving equipment—you can overcome excess noise, vibration, shaft-wear, misalignment and similar problems by designing Flexible Bearings by Bushings, Inc. IN as original equipment.

FLEXIBLE BEARINGS are custom-fabricated to your specifications. With the bushing manufactured to fit the job, you are no longer restricted to limited "stock" sizes but have complete freedom of design.

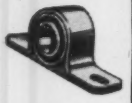
FLEXIBLE BEARINGS by Bushings, Inc. have a mechanical bond between the flexing medium and the inner and outer members.

FLEXIBLE BEARINGS by Bushings, Inc. are available in two types; TORSIONAL for oscillating movement; PROTECTIVE for insulating ball, needle and other types of bearings against load, sudden shock, misalignment or noise transmission.

If you want fast, authoritative engineering help on your bearing problems, write Harvey G. Moore at the address below.

• *For more than 15 years Bushings, Inc. has custom-fabricated bearings in a wide range of metals and sizes for hundreds of different manufacturers.*

VIBRO-LEVELER MOUNTS dampen vibration, permit precision leveling of machines.



SILENT-LIGN PILLOW BLOCKS for shaft mounting. Has all Flexible Bearing features.

Bushings, Inc.

4358 COOLIDGE HIGHWAY • ROYAL OAK, MICHIGAN

Circle 618 on Page 19

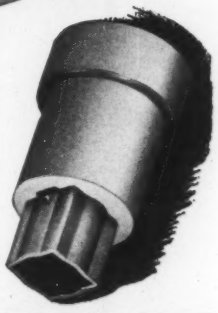
High-Impact-Strength High Temperature

BRUSH HOLDERS

New PHOENIX "Pemester"

High performance Phoenix "Pemester" Brush Holders and Caps are for motors that get the really rugged duty... new "Pemester" material gives high-impact-strength, dimensional stability up to 400°F. and molds to close tolerances in any quantity . . . Available *only* from Phoenix in the complete "Customized-Standard" line of sizes and types—or to your specifications.

Write for full information contained in big, new, easy-to-use Phoenix Catalog 57-L. Your copy free on request.

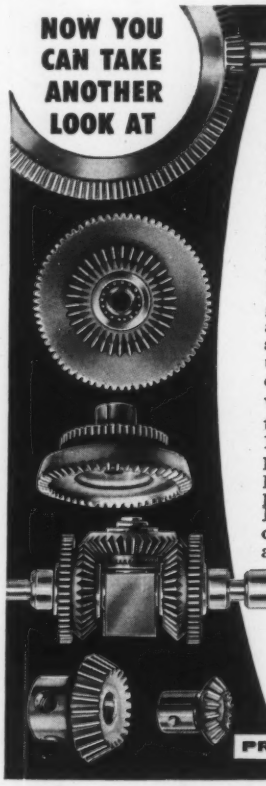


PHOENIX ELECTRIC MANUFACTURING CO.

4211 West Lake Street Chicago 24, Illinois

Circle 619 on Page 19

NOW YOU CAN TAKE ANOTHER LOOK AT BEVEL GEARS



Designers can now re-consider the use of bevel gears—due to the latest Gleason coniflex system of bevel gear proportions which we employ—to minimize gear mounting problems and for less trouble after assembly. Costs are less by this method, better finishes and smoother gear operations are a result, and because bevel gears are so efficient, they can now be used more extensively than ever before.

We can make bevel gears up to 3" in diameter with up to 16 diametral pitch for such products as instruments, power tools, differentials, appliances, and fishing reels. Process bevel gears are precision engineered, deliveries are prompt.

Send blue prints or specs for prompt estimates to the specialists in the Fine Pitch Field.

108

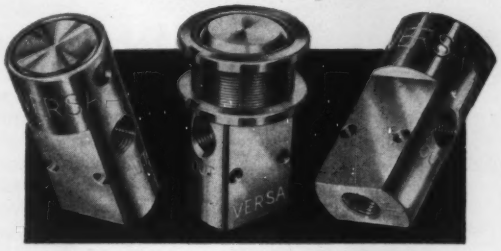
PROCESS GEAR CO.

4608 W. Fullerton Ave. • Chicago 39, Ill.

Circle 620 on Page 19

Versa "A" Valves

Give MAXIMUM Capacity In MINIMUM Space...



- Versa solves the space problem with a truly economic valve.
- The overall size of the Versa "A" valve is only 2" high by 1" in diameter, yet it has the capacity of much larger valves.
- Ideal for controlling cylinders, instruments and larger pilot valves.
- Available in ⅛" NPT in 2-way & 3-way types with or without button guard, in either normally open or closed models.
- Simple to mount on equipment or can be furnished for panel mounting.
- Prices range from $4.00 to $6.50 each. For complete information write today for Folder #14S.

VERSA

VERSA PRODUCTS COMPANY INC.
247 SCHOLES STREET, BROOKLYN 6, N.Y.

FREE CATALOG! Write today for your free copy of Versa's Catalog #14.

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BROWNING FHP SHEAVES

the most extensive line on the market!

Only Browning offers you all three kinds of sheaves: **Die Cast** for light duty, low initial cost. **Pressed Steel** for sturdy, rugged service at medium price. And **Cast Iron** for heavy duty, highest quality, greatest value; with fixed bore or Browning's famous interchangeable split taper bushing. Choose the sheave most efficient and economical for your every job from Browning's complete range of stock sizes.

Ask your Browning distributor or write us for Catalog V147.

Browning MANUFACTURING COMPANY
MAYSVILLE, KENTUCKY

Circle 622 on Page 19

specify ATLANTIC METAL HOSE

Atlantic flexible metal hose is JOB TESTED & CERTIFIED to withstand the most extreme conditions of temperature, pressure and rough usage. Wall thickness is absolutely uniform. Atlantic hose cannot kink, deteriorate or burst — and requires no maintenance.

Available in steel, bronze, monel and various alloys of stainless steel with proper fittings.

Write for Bulletin No. 500A. See our Catalog in Sweet's Product Design File. Specialized engineering consultation available.

Type BD-15 Convoluted-Size 3/16"-12" I.D.

Type BD-20 Convoluted-Size 3/16"-1½" I.D.

Type A-1 Corrugated-Size 3/16"-4" I.D.

Type SW Corrugated-Size 1"-20" I.D.

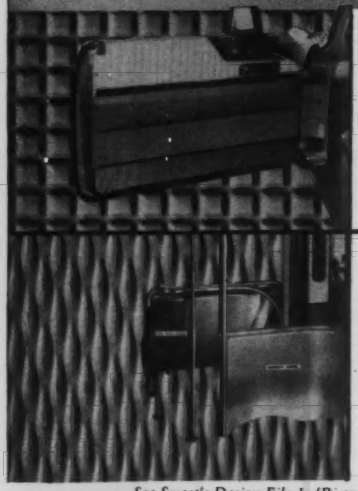
ATLANTIC METAL HOSE CO. INC.
318 Dyckman St., New York 34, N. Y.

Circle 623 on Page 19

RIGID-tex METAL

demonstrates its Superiority

ON THE ROAD



Where kicks and scuffs are routine—RIGID-tex Metal will take it and remain new looking always—like the kick-plate on this modern automobile door. (Pattern 1-SQ)

Bus seat backs of stainless RIGID-tex Metal (pattern 5-WL) withstand kicks, scuffs—even knifing. Reduces maintenance costs. Used too for modesty panels, treads, etc.

See Sweet's Design File 1a/Ri or write for more information.

RIGIDIZED METALS CORPORATION

69312 OHIO STREET, BUFFALO 3, N. Y.

World-wide Distribution

Circle 624 on Page 19

DRIV-LOK STUDS

Save 60% Fastening Time!

- HOLD PERMANENTLY
- DISASSEMBLED EASILY WITHOUT DAMAGE TO COMPONENTS

Quick, simple insertion . . . Drill Hole and Drive Stud with a single blow.

TYPICAL APPLICATIONS

Attaching name plates or instruction panels

Fastening spring assemblies or control arms.

Widely used for fastening brackets.

Securing semi-permanent covers and closure plates.

3 HEAD STYLES

Round (standard) | Flat (to order) | Countersunk (to order)

Driv-Lok Studs save time and reduce costs in fastening name plates, covers, brackets, panels, etc, to heavier sections and for countless other applications involving light-to-heavy member fastening. Once installed, Driv-Lok Studs will not vibrate loose or fall out—yet they can be easily removed without damage to components. Made in 3 head styles. Write for illustrated catalog sheet, prices and samples.

DRIV-LOK PIN COMPANY

715 Chauncey St. • Sycamore, Ill.

Circle 625 on Page 19

FREE SAMPLES and APPLICATIONS of INDUSTRIAL FELT*

*made to S.A.E. and Federal Govt. Specifications

See why **CONTINENTAL FELT** fills hundreds of jobs daily

SEE HOW FELT FITS IN WITH YOUR PRODUCTS

Ask for booklet M-12

CONTINENTAL FELT COMPANY, INC. 1905

22-26 WEST 15th STREET NEW YORK 11, N. Y.

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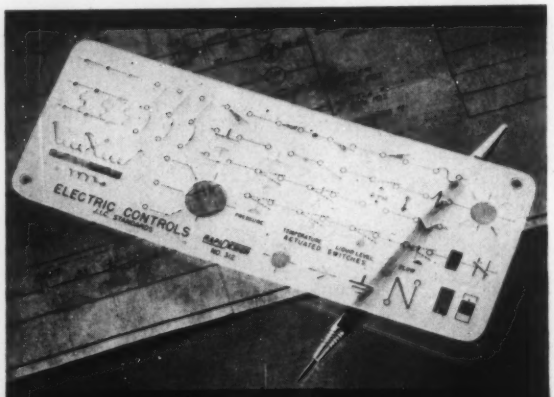


NO. 312 ELECTRONIC CONTROLS TEMPLATE

ACTUAL SIZE 9" X 3⅜"

J. I. C. STANDARD SYMBOLS AS RECOMMENDED BY THE JOINT INDUSTRIAL CONFERENCE IN MARCH 1953.

DESIGNED TO ASSIST IN THE DEPICTION OF CIRCUITS IN ELECTRICALLY CONTROLLED MACHINERY AND ELECTRIC AUTOMATION OF PRODUCTION PROCESSES.

MADE OF .030 MATTE FINISH MATHEMATICAL QUALITY PLASTIC.

ONE OF THE MORE THAN FIFTY RAPIDESIGN TIME-SAVER TEMPLATES – ALL OF WHICH ARE BETTER MADE, MORE USEFUL AND LESSER PRICED.

$2.50 AT YOUR LOCAL DEALER

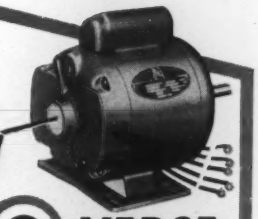
CATALOGUE NO. 55 AVAILABLE UPON REQUEST

RAPIDESIGN INC.

P. O. BOX 592 • GLENDALE, CALIF.

Circle 627 on Page 19

Franklin's NEW INST-O-VERSE



INSTANT—REVERSING MOTORS
. . . instantly utilize full torque capacity.

Franklin Motors with INST-O-VERSE® apply full power for instant reversing in response to manual or automatically transduced demand.

Available to OEM in 1-Ph., 1725 r.p.m., 115 or 230 V., sleeve or ball bearing, NEMA or special mountings, 1/6 through 1 H.P. Performance-proved for hi-reliability applications. Write for data.

FREE COLOR FOLDER GIVES DETAILED OPERATING DESCRIPTION . . .

MD

Franklin Electric Co., Inc.
BLUFFTON, INDIANA

PATENT PROTECTED

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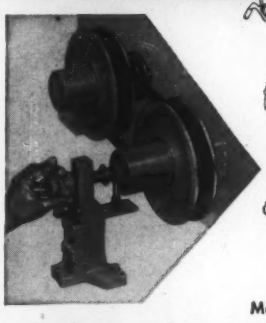
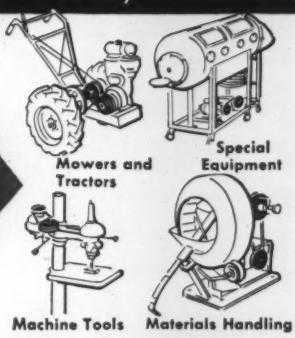
SPEED SELECTOR
VARIABLE PITCH SHEAVES
Control Speeds on Variety of Machines





Wide Speed Range! Low Cost Sheaves

Speed Selector Sheaves can give your machines or equipment extra wide-range speed control on fixed centers. Efficient, rugged, simple to use — low in cost! Write for Illustrated Bulletin.

CATALOG FREE! WRITE TODAY

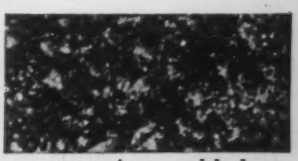
SPEED SELECTOR INC.
P.O. BOX 312-B • CHAGRIN FALLS, OHIO

Circle 629 on Page 19

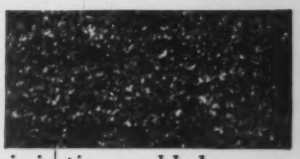
problem: *who makes long-lasting rubber O-rings of ±.002" tolerance at low cost?*

answer: *minnesota rubber and gasket company*

evidence:



compression molded



injection molded

Minnesota Rubber O-rings are injection molded by the exclusive Minnesota Rubber process. Result is increased resistance to abrasions and chemical actions due to consistent, unequalled high density. Evidence of the greater density of injection molding is shown here in cross sections of Standard Buna N compound, .026" x .019", magnified 240 diameters by University of Minn.

In addition, Minnesota Rubber's O-rings have no flash. Tolerances can be kept within ±.002 inch. Cost? M.R. O-rings cost as little as ordinary O-rings! And M.R.'s 100% inspection and quality control save you additional money in replacement costs, too.

free samples and data:

Free samples of Minnesota Rubber O-rings are available together with technical information and installation data.

minnesota rubber and gasket company

Originators of modern rubber injection molding
Dept. 806, 3630 Wooddale Ave., Minneapolis 16, Minn., WEst 9-6781

Circle 630 on Page 19

AJUSTRITE®
DRAFTING CHAIR

Three Sizes
20" x 28"
24" x 32"
28" x 36"

- 2" Upholstered Seat
- No Soiled Hands Adjusting Seat
- 2-Way Adjustable Back Rest
- Full Swivel Seat

Model
RUC 2230

***Just Right* for**
COMFORT•UTILITY•PRICE

The AJUSTRITE CHAIR enables the user to quickly and easily adjust the height of the seat up or down to suit his individual requirements—without soiling his hands.

The 2-way posture adjustment of the back rest assures a relaxed position free of strain and tension.

Also available with round metal or wood seat, formed plywood or solid hardwood saddled seat. Gray or green finish optional.

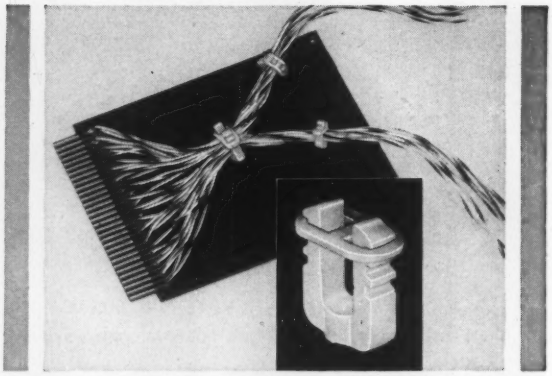
AJUSTO EQUIPMENT CO.
515 Connecut Street **Bowling Green, Ohio**

FREE TRIAL

Use AJUSTRITE Chair or Stool for 30 days without obligation. Prove to yourself the many advantages AJUSTRITE offers. Guaranteed against failure due to defective material or workmanship for a period of 10 years.

SPLIT SECOND
ADJUSTMENT
. . . to any Height Desired

Circle 631 on Page 19



new Zytel wire clamp cuts weight in planes and missiles

This unique wiring clamp weighs only 0.001 lbs. for 3/16" capacity handling 58,000 circular mils . . . only 0.052 lbs. for 2-1/2" capacity handling 8,570,000 mils. It resists fatigue in any position, and withstands loadings up to 50 g's. Easy installation—place wire bundle between U-shaped horns; push down the keeper—it locks, with permanent holding power. Sizes range from 3/16" to 2-1/2" across the horns.

for further information request data sheet.

DAKOTA
ENGINEERING INCORPORATED
6641 Crenshaw Blvd., Los Angeles 43, California

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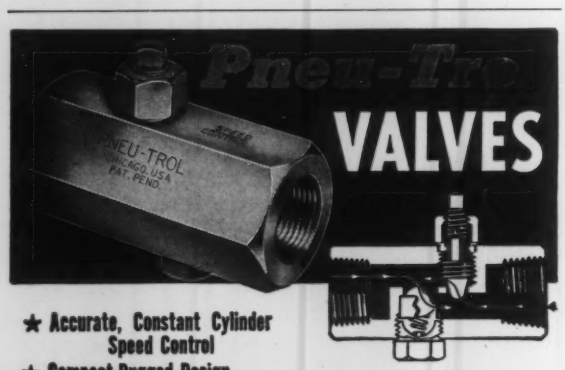

★ Accurate, Constant Cylinder Speed Control
★ Compact Rugged Design
★ Simple, Easy Speed Selection ★ For Air, Oil or Water Applications

Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

Needle design permits maximum flow capacity in the controlled direction. Metal to metal needle and ball seats insure long trouble-free service. Simple, practical "O" gland structure eliminates troublesome leaking. Valve bodies machined from hex brass or aluminum for 2000 psi working pressures; steel and stainless steel for 5000 psi. Made in 5 female pipe sizes—⅛" to ¾". ATTRACTIVE PRICES . . . IMMEDIATE DELIVERY.

Write for illustrated circular and prices.

Pneu-Trol DEVICES, INC.
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Here's BIG HELP IN
TERMINAL WIRING!

The correct wire to correct terminal every time!

The New
JONES FANNING STRIP

Connections are made through Fanning Strip, on bench or anywhere apart from barrier strip, and quickly slipped into assembly.

Designed for use with Jones Barrier Terminal Strips Nos. 141 and 142, for 1 to 20 terminals.

9-141 Barrier Strip

Simplifies and facilitates soldering. Insures positive correct connections. Saves time, ideal for harness or cable assembly. Strong construction: Brass terminals, cadmium plated. Heavy bakelite mounting.

● 9-161 Fanning Strip. Pat. applied for.

Send for complete data on this new basic improvement!

Jones
HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 24 ILLINOIS
SUBSIDIARY OF UNITED CARR FASTENER CORP.

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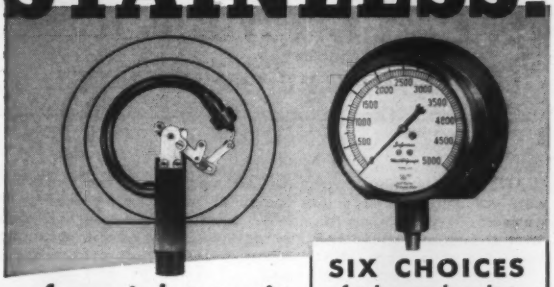
STAINLESS!



—from inlet to tip

Now the superlative Mastergauge is available in a wider range of corrosion resistant tubes and sockets than any other pressure gauge.

Check the adjoining list. And remember that tube socket and tip are fused into one piece by the exclusive Marsh "Conoweld" process.

Marsh alone combines the "Conoweld" construction, the copper-clad "Marshalloy" case, the finer Mastergauge movement, the Marsh "Recalibrator", the new "Safecase." Ask for data covering your specific needs.

SIX CHOICES
of tubes and sockets

4130 alloy steel tube with alloy steel tip and socket.

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Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyrighted 1957 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

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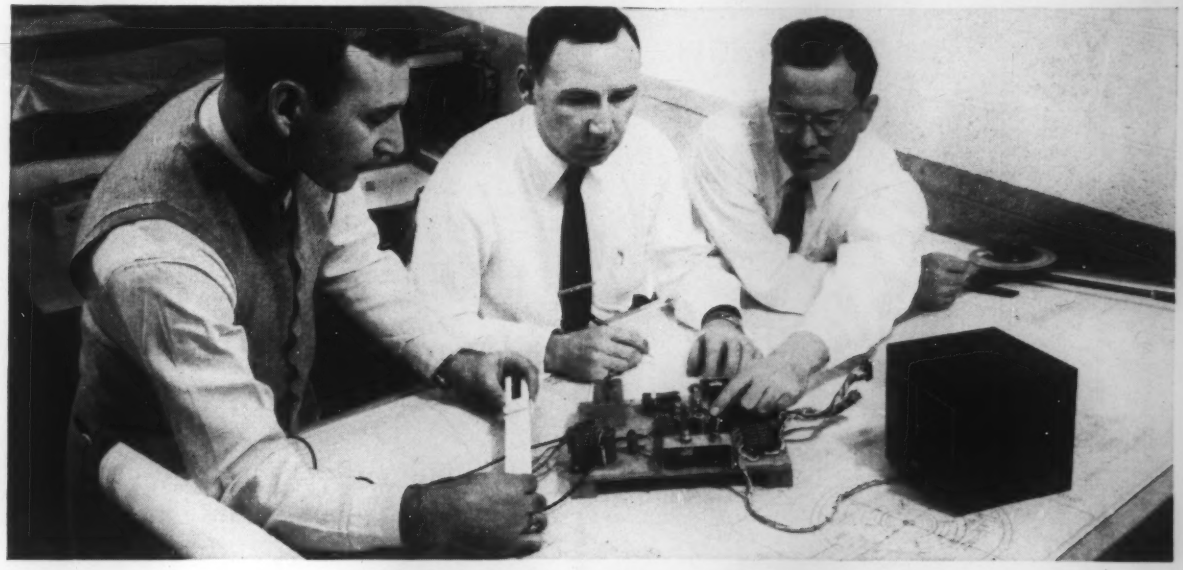

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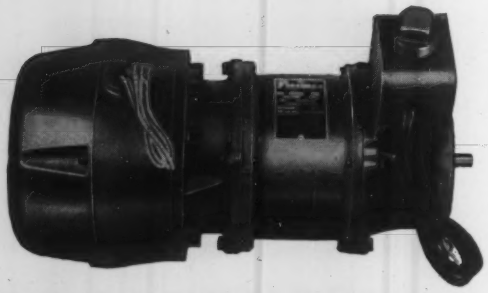

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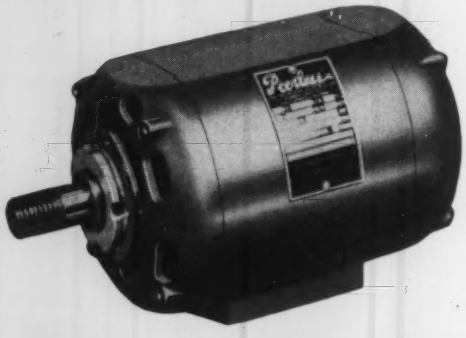

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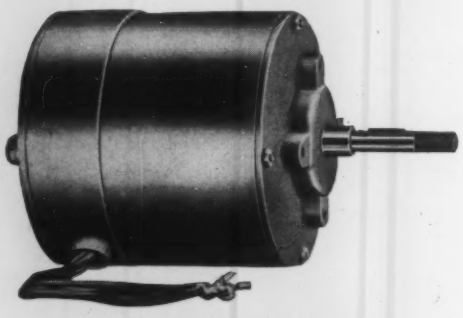

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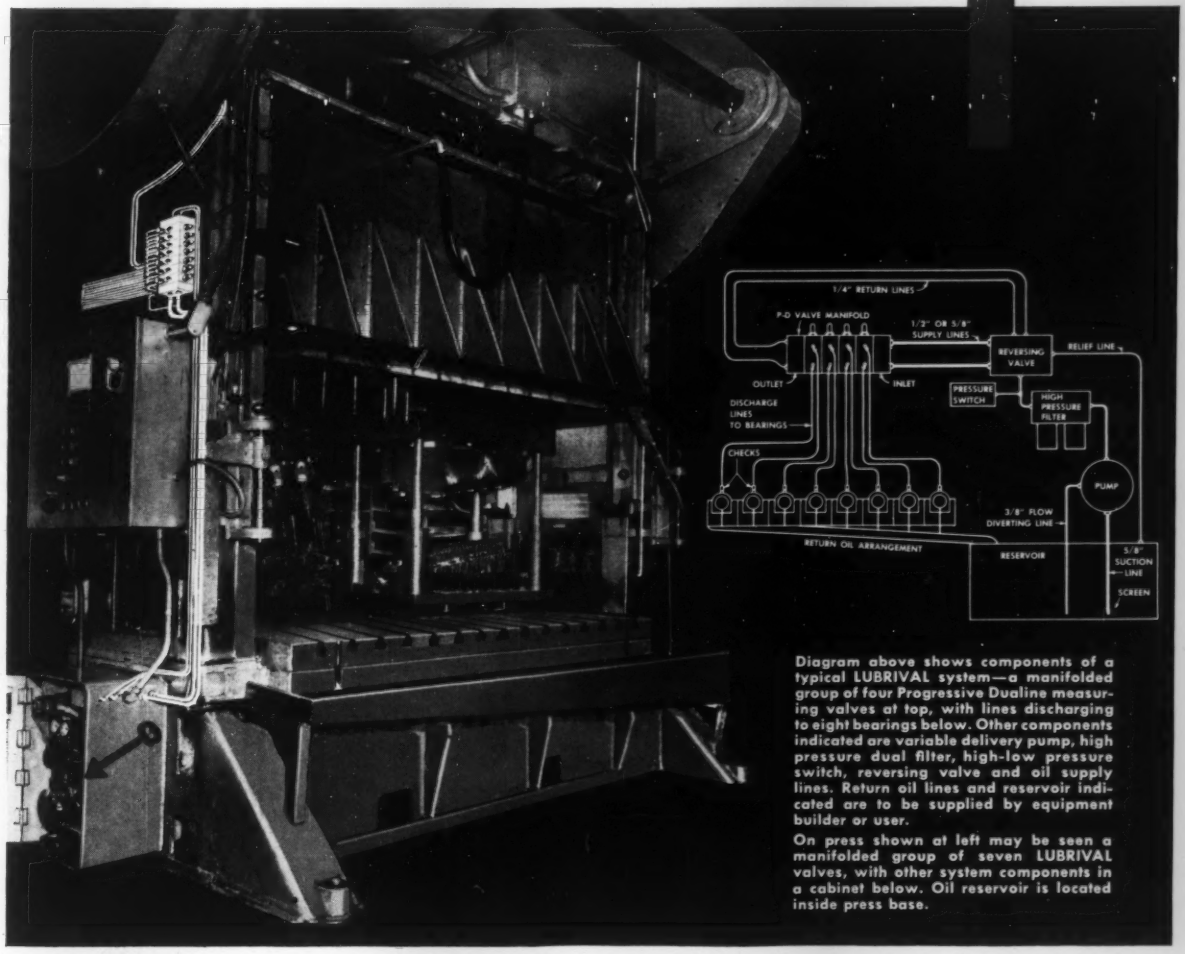

Diagram above shows components of a typical LUBRIVAL system—a manifolded group of four Progressive Dualine measuring valves at top, with lines discharging to eight bearings below. Other components indicated are variable delivery pump, high pressure dual filter, high-low pressure switch, reversing valve and oil supply lines. Return oil lines and reservoir indicated are to be supplied by equipment builder or user.

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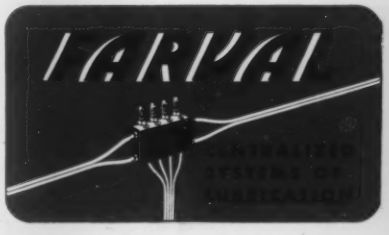

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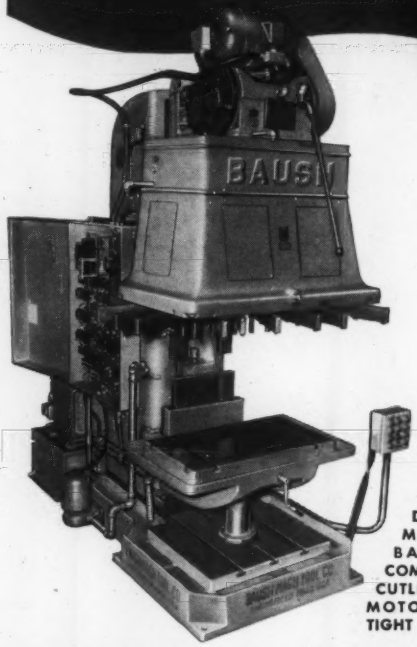

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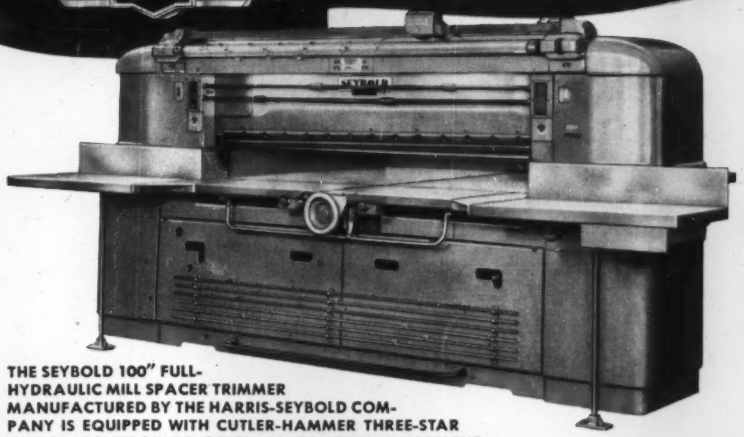

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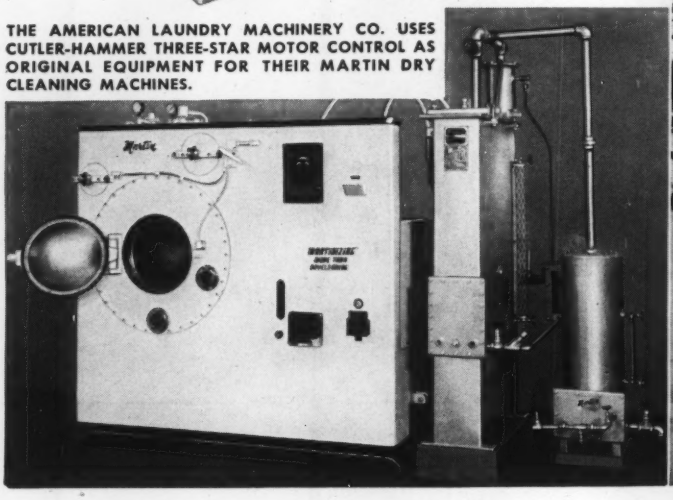
THE AMERICAN LAUNDRY MACHINERY CO. USES CUTLER-HAMMER THREE-STAR MOTOR CONTROL AS ORIGINAL EQUIPMENT FOR THEIR MARTIN DRY CLEANING MACHINES.



THIS REX SLUDGE COLLECTOR BUILT BY THE CHAIN BELT COMPANY IS SUPPLIED WITH CUTLER-HAMMER MOTOR CONTROL.

Look to the Stars for Satisfaction

Motor control equipment plays an important part in the performance and dependability of modern machines. None know this better than the machinery builders who have won positions of leadership. Only superior performance can create such reputations.

Experienced machine buyers know this is true and they look to motor control as a guide in making their selections. They know Cutler-Hammer Three-Star Motor Control does much more than provide assurance the electrical equipment is trustworthy. They know it reveals the standard to which machines are designed and built.

When you buy machinery, note how often Cutler-Hammer Three-Star Motor Control is not only offered but featured by leading machinery builders. Look to the Stars for satisfaction. CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate*: Canadian Cutler-Hammer, Ltd., Toronto.

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